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ELECTROTYPE MANIPULATION:

PART I.

BEING

THE THEORY, AND PLAIN INSTRUCTIONS

IN THE ART OF

WORKING IN METALS,

BY PRECIPITATING THEM FROM THEIR SOLUTIONS,

THROUGH THE AGENCY OF

GALVANIC OR VOLTAIC ELECTRICITY.

BY

CHARLES V. WALKER,

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THE ELECTRICAL MAGAZINE, KÆMTZ'S METEOROLOGY, &c. &c.

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PREFACE

TO THE LATER EDITIONS.

The rapid sale of the earlier editions of this Work can only be traced to the great popularity of the subject on which it treats.

No branch of Experimental Philosophy has been more cultivated than Electrotype. Like all, it is replete with interest, whether examined in its theory or in its results,—unlike some, it leaves a trace of its footsteps,—a tangible evidence of its power. I allude not to its profitable applications in the hands of the artisan; furnishing, as they do, a full and forcible reply to the oft-proposed question "What is the *use* of Electricity?" For him these pages are not written;—his demands upon the art are of another nature, and are intimately connected with his own resources. I write for him who delights to devote a portion of his hours of relaxation to the study of those mysteries of nature, into which the eye of science has been able in a degree to penetrate. It may be safely said that in the length and breadth of England, the proportion of such individuals is far greater than else where; there is amongst us a national love of *home* and of *home*-occupations; and when we do wande we feel that we *are* wanderers; and can regard wit pleasing anticipation the time which will return us t our *home*. Amongst home attractions is ever foun a taste for the fine arts; this is seen even in th cottage, whose walls are adorned with "much th taste, untaught and unrestrained, surveys delighted; the inmate of the humble tenement, "around who walls are heroes, lovers, kings," surveys them with satisfaction closely akin to that which animates th man of cultivated taste, as he views the perfect pr ductions of a Raphael or a Correggio. This taste abundantly gratified by the discovery of Electrotyp it enables each, who desires it, to furnish himself wi durable copies of the finest productions of the chis and the graver. He finds an inexhaustible field op before him;—and, if he devote his time to formin collections, he is animated at every step by the novel and interest attached to each fresh acquisition. A not the least feature of interest allied to a collecti thus formed, is the fact that every specimen is stamp with a double signature of "mine,"—"mine" it is *possession*,—but especially it is "mine" by *productio*

When I consider how many copies of this treati have, during the last year or two, been dispers through all quarters of our land (and not *ours* only *I cannot* but feel that it has been in some m instrumental in enabling very many to tread the same pleasing path that I have trodden. I trust my endeavours to pave the way have not been unsuccessful. On first venturing along the new-discovered road, I found many a stumbling-stone besetting my steps; and many a time have I had to survey before I could tell which track would lead to the desired end. These obstacles I have endeavoured to remove from the path of those who are interested in following the traces marked out; I have, too, watched with care the progress made by others; and have in each successive edition embodied as much fresh information as conveniently I could. To my more mature experience on the subject of mould-making; to the general principles on which the reduction of metals is based; and to the description of new arrangements of apparatus which, with revisions of many paragraphs, were given in the earlier editions, I have, in this, added all the improvements, up to the present time, that I could conveniently compress into these pages.

It was at first my intention* to have added observations on the deposition of other metals; this, however, was not found possible; there was so much to be said that could not be contained within the present pages, that I rather determined to unfold fully the principles and practice of the art in this treatise, and to prepare a Second Part, to be devoted to plating, gilding, etching, and all the several applications of the art, which,

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[*] Preface to Fifth Edition.

for want of space, could not be introduced here. In Part II. will also be found the etching of Daguerréotype plates, and several modifications in Voltaic apparatus. In the FOURTH Edition of Part II., Electro-Printing is introduced; and the process of plating and etching are dwelt upon more fully.

CHARLES V. WALKER.

Westbourne, August, 1844.

PREFACE

TO THE EIGHTEENTH EDITION.

To the former Editions of this little Treatise, so many additions had been made, that the arrangement had become somewhat irregular. In preparing, therefore, the SIXTEENTH EDITION, I re-arranged the whole, re-wrote many parts, and added several interesting facts that recent investigations have brought to light. The same are continued in these later editions.

C. V. W.

Tonbridge, June 1847.

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ELECTROTYPE MANIPULATION.

I. Introductory Observations.

1. The object of the present treatise is not so much to dwell upon the philosophical principles on which the art of electrotype is based, as it is to trace in a familiar manner the several processes in manipulation, and the precautions to be observed in order to escape failure. The instructions given are the results of a long course of experiment; and it will be the especial aim of the writer to dwell minutely upon those *little* points which so materially influence the success of the experiments. It will be the endeavour to avoid, as much as may be, the use of scientific phraseology; so that the amateur, for whose use this work is written, may find as few obstructions as possible besetting his path. In the course of forming a large collection of medals by the Electrotype process, and copying casts of large size, the author has, of necessity, been led to adopt such modes as convenience and economy dictated. These will be described in order, as the reader is led from the original medal to the perfect copy, ready for the cabinet.

2. Galvano-plastic, Electrotype, or Electro-metallurgy, is, as its several names indicate, intimately connected with Galvanic, or, as it is more fitly termed, Voltaic Electricity. In order, therefore, to convey correct notions on the subject, it will be requisite, before entering on it further, to give a brief outline of the *principles of* this science, and to trace their *application to the* art in question.

3. *Voltaic Electricity.*—Galvanism, or Electricity, is the name given to that develo electricity discovered in the year 1790, by Galvani, of Bologna, and subsequently more vestigated by the labours of Volta, whose lett Joseph Banks, the then President of the Royal announcing the discovery of the apparatus, na him the Voltaic pile, is dated March 20th, 18 obtained by certain arrangements of metals an of which the following may be taken as an ill If a piece of zinc and another of copper be one to each end of a wire, and the two be th in a vessel containing water, acidulated with acid, it will constitute a simple *or single vol* IN ACTION.

4. The action is dependent on the different affinity of the liquid for the respective metal dissolve the zinc—it will not dissolve the co other words, the water (which is well known of the two gases, oxygen and hydrogen, c combined) is decomposed;—the *hydrogen* escape at the surface of the *copper* plate in th gas; the oxygen *combines* with the zinc, and *oxide of zinc;* this oxide unites with, and is in the sulphuric acid, forming *sulphate of z* tions analogous to this occur in *all* voltaic tions. The exciting liquid has a *greater* a one metal than for the other. The former the *positive* metal; the latter the *negative.*

5. For most practical purposes, zinc is u positive metal,—either pure zinc, the zinc of c or amalgamated zinc. (§ 46.) For the negat copper is generally used; but a very conv rangement has been devised by Mr. Alfred Sm wherein platinized silver—silver covered wi particles of platinum—is employed. Anoth has been constructed by Professor Grove, *powerful* nature, wherein plates of platinum There is also a modification of this latter,

zinc and charcoal. Charcoal, or carbon, being the only other substance in nature—not metallic—which can be so employed.

6. I have here spoken (§ 4.) only of the *chemical* change which takes place; but in connection with this, and bearing a strict relation to it, is another phenomenon of the highest interest,—namely, the disturbance of electric equilibrium.

7. During the continuance of the chemical changes already described, (§ 4.) a transfer of electricity is quietly taking place between the two metals. The positive electricity (which, to avoid circumlocution, we will assume to be, as possibly it is, *the* electricity) passes *from the zinc through the liquid to the copper*, and then continues its course along the wire (§ 3.) by which the metals are joined, to the zinc again. If the wire is broken, the transfer of electricity is interrupted, and the chemical effects, so far as electricity is concerned,* cease; hydrogen is no longer evolved from the copper plate, and the zinc (if it is pure or amalgamated) ceases to be dissolved.

8. The fundamental principle, which cannot be too strongly enforced, is that the passage of the electricity *in the liquid* is *from* the zinc *to* the copper. If this simple fact is borne in mind, it will decide in every case the question which confuses so many—namely, —which is the positive, and which is the negative end of a battery? The positive is the end where the electricity *leaves* a battery; the negative where it *re-enters* it. The direction taken by the current being ascertained by the mere inspection of the situations of the two metals *in* a cell, the other points follow as a necessary consequence.

9. If, for instance, the wire connecting the two plates, (§ 3.) by which we have illustrated a single voltaic pair, were broken, and the circuit completed by interposing some apparatus between the broken ends,

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* The *ordinary* chemical effects of the acid on the zinc continue, *unless prevented* by other means. (§ 46.)

an examination of the arrangement would at once show, that as the electricity passes *from* the zinc *to* the copper, it would leave the battery by the wire attached to the *copper* plate, and, having passed through the interposed apparatus, would return to the battery by the wire attached to the *zinc* plate; the copper, which is the *negative* metal, forming the *positive* end of the battery; and the zinc, the *positive* metal, forming the *negative* end.

10. *Electrolysis.*—The *great* effects of voltaic electricity, those which have rendered it so attractive a science, are produced by the various modes of combining a large or small number of these pairs of metals, and on the nature of the apparatus interposed between the wires connected with the respective ends of the arrangement. The power, which from its effects Dr. Faraday has termed the Electrolytic* power, is that which alone demands *our* attention, because on the right understanding of this depends the successful application of the art of Electrotype.

11. If a series of about ten of these voltaic pairs or batteries be arranged in the order of zinc, liquid, copper, and the terminating wires, which for this purpose should be of platinum, be placed in a vessel of water containing sulphuric acid,† the water will be electrolyzed or decomposed by electricity; the hydrogen gas will be released at the wire connected with the negative end of the battery, and the oxygen at that connected with the positive. If these gases be collected separately in tubes placed over the platinum wires, the quantity of hydrogen will be double that of the oxygen.

12. If into this acid liquid some crystals of sulphate of copper be thrown, and the current be sent through, electrolysis will still take place,—the water will still be decomposed, but only *one* of the gases, the *oxygen*, will

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* Vide Exp. Researches. Series 7, § 664.

† *In this* and all other similar instances the use of sulphuric acid *is to increase the* conducting power of the liquid;—to facilitate the *passage of* electricity through it. The modus operandi cannot be *ed into here.*

be obtained. The hydrogen, as it becomes released from the water, will take the place of the copper in the solution, and the *copper* will be liberated and become visible on the negative (§ 8.) wire. This experiment may be continued till all the copper is abstracted from the solution: the remaining liquid will be water, strongly acid.

13. A third modification of this experiment is by using for the positive wire, one of *copper*, instead of *platinum*. In this instance, too, the water is decomposed; but *neither* of the gases is visible. The hydrogen, as before, occupies the place of the copper in the solution, releasing the copper as in the last experiment; (§ 12.) the oxygen, instead of appearing at the positive wire, combines with the copper of which it is composed, forming an oxide of copper: this oxide unites with the sulphuric acid, and forms a sulphate of oxide of copper. In proportion as the solution is weakened by the release of copper at the *negative* wire, it is thus supplied with copper from the *positive*. If, in these experiments, a measuring instrument had been included in the circuit, it would be found that the first of the three presented the greatest resistance, and the last the least. For, in the last case, the chemical forces were made to conspire with the electric current.

14. It will be observed, in these illustrations of electrolysis, that the metals are released at the *negative* plate. One part of the science of Electrotype,—a science discovered in England by Mr. Jordan and Mr. Spencer, and on the continent by Professor Jacobi, consists in preparing for a negative plate models or moulds (§ 20 &c.) of objects to be copied; and in so arranging the battery, or apparatus which generates the voltaic current, (§ 43 &c.) as to release the metals in a compact and solid form.

15. On these two points many precautions are to be observed; but a faithful compliance with the directions to be *given will* enable the least skilled to obtain *metallic copies of* the most beautiful works of art, by *merely exercising* ordinary care and a little patience.

16. *Constant Voltaic Battery.*—Before closing these preliminary observations, it will be requisite to give a brief description of the Constant Battery. The voltaic pair immersed in a cell of acid water (§ 3.) is liable to some objections. First: The bubbles of hydrogen released on a common copper plate partially adhere, and of necessity prevent portions of this plate from being in actual contact with the liquid; and hence its power is less than it might be. The dissolved zinc, too, is partially released and deposited on the copper or negative plate, according to the laws already illustrated (§ 13.); hence arise counter-currents, which weaken the force.

17. The late Professor Daniell, by the invention of his constant battery, has enabled us to overcome in a very great measure these difficulties,—to remove these objections. The deposition of the zinc is obviated by using two liquids, separated by a porous partition, or, as it is called, a diaphragm, of animal membrane, paper, (§ 44.) earthenware, plaster of Paris, wood,* &c. (§ 48.) The liquid contiguous to the zinc is, as before, (§ 11.) acidulated water; that near the copper is a solution of sulphate of copper.† By this arrangement, it will be seen, from what has been already stated, (§ 13.) that *copper* will be released, in place of *hydrogen* on the copper,—the negative plate.

18. The *continuous* action of this battery is preserved by *amalgamating* (§ 46.) the zinc, and supplying the cupreous solution with crystals of sulphate of copper. (§ 50.) The former prevents the acid acting *chemically* on the zinc (§ 7.) and destroying it uselessly: the latter keeps up the strength of the solution, which is being constantly exhausted by the reduction of the copper. Fresh acid water is occasionally added.

This instrument is termed a *constant* battery, from its power of continuing a generally steady action for a *lengthened* period of time. It has been constructed in

* *Lime-tree or* some other porous wood, boiled for an hour, *at least, in water containing* a little sulphuric acid.—Jacobi.

† *This is more properly* termed sulphate of oxide of copper.

various ways, being modified according to the taste of individuals, or to the use to which it is to be applied. But whatever *form* may be given to it, it is still the constant battery, invented by Professor Daniell, to whom alone the credit is due for devising so valuable an arrangement. The annexed woodcut represents a cell of a Daniell's battery. The cell, being of copper, itself forms the negative metal. A rod of amalgamated (§ 46.) zinc is placed, as shown in the figure, within a tube of porous earthenware. Attached to each metal is a binding screw, to form connections. A cell of this description is put into action by placing its several parts as shown in the figure; filling the porous tube containing the zinc with a mixture of one part sulphuric acid, and ten parts water; and filling the copper cell with a saturated solution of sulphate of copper.—By *saturated* is meant a solution containing as much of the salt of copper as the water will take up. This is prepared most readily by pouring boiling water on a superabundance of crystals of sulphate, and stirring them; to this solution one-tenth acid should be added. The perforated metal shelf, shown in the figure, is to support a supply of crystals to recruit the exhausted strength of the battery. (§ 50.) The crystals are placed thus *high up* in the liquid, because the upper portions are exhausted *first;* the specific gravity keeps the strong parts of the solution below.

19. *Note on Voltaic Batteries.*—While on the subject of voltaic pairs, it would be as well to pen a few lines on those powers of the battery, not directly connected with the art of Electrotype.—If a cell of the constant battery be charged as directed above, and a piece of fine platinum wire be stretched from the screw attached to the zinc, to that attached to the copper, it will attain a red or a white heat. This is termed the "heating *power" of* a battery. The larger the cell, the greater *thickness of* wire will be heated. If too thin a wi

be used, the passage of the electricity will be so much retarded as to produce no visible indications of heat. The *length* of wire that can be heated depends on the cooling power of the contiguous *air*; " a current that will heat one inch of platinum, will heat a hundred inches."* The law which regulates the comparative length of wires heated by different combinations of the batteries is this: If one such cell as that described, heats x inches, and another cell y inches, the two arranged in series will heat $x+y$ inches.†

If a series of cells be arranged, as in the annexed figure, by uniting the copper of one to the zinc of the other, and points of charcoal be attached to the terminating wires, upon bringing these points into contact and then separating them, the well known phenomenon of the voltaic flame is produced. The *length* of this flame depends on the number of cells *used; the size* or *thickness*, (if we may use the term,) on

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* *Faraday's* Researches. Thirteenth Series. § 1631.

† *Transactions* Electrical Society, p. 63. § 36.

the size of the cells. The flame from a hundred cells is very brilliant; in some experiments made with a series of upwards of three hundred, it was needful to screen the eyes with a black silk veil. Few things resist the intense heat of this flame; the metals are speedily dissipated in fumes; platinum and gold are melted and vaporized. The arrangement of cells in series will produce a shock on the human frame, intense in proportion to the *number* in the series. Thirty will produce the effect: three hundred will produce more than a man with ordinary nerves could endure. The electrolytic power of the battery is only manifested on bodies in solution, or on bodies made liquid by heat; and these several bodies are acted upon with various degrees of facility. Solution of iodide of potassium is most easily decomposed. A battery consisting of a mere *wire* of zinc and one of copper, will decompose this solution, even by means of *platinum* wires. Water is more difficult of decomposition. Ten cells of a Daniell's battery are a convenient number to effect the decomposition of this. A series of twenty will release very little more gas than one of ten; but *two* series of ten placed *side by side* will do twice the work of *one* series. By an arrangement of this kind it is that the maximum of decomposing power is obtained from a given number of cells. Chloride of lead or silver, or chlorate of potassa, &c., &c., do not conduct the current in their solid state, and therefore resist decomposition; but, when made fluid by heat, they obey the same general law as do solutions. When sulphuret of antimony is fused by a powerful voltaic flame, the heat of the same current will keep it fused, while the current itself decomposes it.—One or two thousand cells containing pairs of plates (copper and zinc) connected in series, and charged with water, produce effects closely analogous to those obtained by the common electric machine. This is termed a water-battery.—There is a beautiful regularity in the action of batteries, that cannot fa to interest the most casual observer: it is a te larity to which the attention of the electrotypist should be especially directed. When a number of cells are connected in series according to the plan represented in the woodcut, precisely the same amount of action occurs in each. If in one an ounce of zinc is consumed, so also is it in every other; and in each, too, a weight of copper is deposited on the surface equivalent to the ounce of zinc. And, if the terminating wires of this apparatus be placed to produce the decomposition of a solution, precisely the same amount of this will be decomposed, as is equivalent to the quantity of zinc consumed or copper released in each cell.—If water be the subject of experiment, the same arrangement of battery will release more or less gas, according to the degree of conductibility given to the water by means of sulphuric acid; the less conductible it is, the greater resistance it offers to the passage of the battery current, the less gas is released, and the less zinc is consumed: as the conductibility increases, the rate of decomposition is higher, and the energy of the action in each battery cell is greater. There is a harmony in all this consistent with what we have hitherto learned of the laws of nature. The knowledge of this law is no small addition to the science of electricity: and it must not be forgotten, that the development of this beautiful system of things is due to an *English* philosopher, whose perseverance in research has been crowned with continued success. Without dilating longer on these general features of the science, I shall pursue the object at present in view, and endeavour, with as much brevity as is consistent, to explain the nature of the Electrotype art, with so much of its theory as, joined with what has been already said, may guide the experimenter safely through each process.

II.—PREPARATION OF MOULDS.

20. I can very reasonably conclude that the amateur *will commence* his experiments on the smaller works of *art; and*, as a knowledge of the mode of manipulatio to copy these will, with a little practical experience, easily pave the way towards accomplishing greater things, I shall dwell principally on the art of copying medals, medallions, seals, &c., taking the reader with me through the entire process.

21. There are many materials fitted for forming moulds; of these—*fusible metal*, *wax*, *stearine*, and a composition whose base is *spermaceti*, are mostly used. The first is applicable to all medals of ordinary size,—the others to plaster medallions and larger medals.

22. *Fusible Metal.*—This is an alloy, consisting of bismuth, tin, and lead; it melts at a low temperature,—a few degrees below that of boiling water: and has been used as a philosophical toy, in the form of spoons, which melt in hot tea. For the latter purpose, it generally contains a small portion of mercury. Since the discovery of Electrotype, it has been prepared for that process without mercury.

23. The proportion of the different ingredients in a pound of this alloy is:—

	oz.
Bismuth	8
Tin	3
Lead	5
	16 = 1 lb.

These should be melted together in a *clean* iron ladle, taking care to keep it on the fire no longer than is necessary to produce the complete liquefaction of the several ingredients. When melted, pour the metal on a stone or marble slab in drops. Then, after having *rubbed the ladle clean* with coarse paper, return the pieces of metal, re-melt them, and pour them out in drops as before. A third melting will ensure the ingredients being well mixed. To retain the metal in a fit condition for use, the ladle must be frequently *rubbed clean*; and must always be removed from the *fire as soon* as its contents are melted. The forme ensures a bright surface to the mould; the latter preserves the alloy from waste by oxidation.

24. *To make a Mould in Fusible Metal.*—Melt some in the iron ladle, and pour it on a slab; then, from the height of two or three inches, drop on it the medal to be copied, taking care that the medal is COLD. In a few *seconds* the metal will be solid, and may be placed to cool; when it is cold, either with or without a few slight taps, the two will separate; and, if proper care has been taken, an *exceedingly sharp* mould will be obtained. The novice must not, however, be disheartened if his first attempts to obtain good moulds fail: for there are so many little accidents which may happen, that the most practised manipulator may have to repeat his attempts. A slight shake of the hand may drop the medal irregularly;—too much sunk, for instance, on one side. A film of oxide may rest on a portion of the surface of the melted metal, and render the corresponding portion of the cast *dull.* Dull looking moulds must always be rejected, for so minutely correct is the process of Electrotype, that the dulness of the mould will be transferred to *every* copy made from it. Even if an original medal be incautiously handled, the slight trace of a finger-mark will be transferred to the mould; and thence to the Electrotype copies.

25. The fusible metal will not always pour into a *round* mass, to receive the medal: unless the slab is perfectly level, it runs into a stream. This is a great inconvenience, but may be remedied by having a shallow cavity (saucer fashion) made in the marble; or by using any article of *earthenware*, which the kitchen or the laboratory may furnish, suited to the purpose. I have been in the habit of using the brown stoneware saucers, in which blacking is sold; and in them have produced some of the best moulds. They *are to* be inverted, and the metal is to be poured on *them.*

26. *Clichée Moulds.*—The following is the mode

adopted on the continent for obtaining the beautiful casts of the French medals, which are so much admired. These casts are in a fusible alloy, containing *antimony*, as well as the other ingredients. (§ 23.) The composition is :—[*]

Bismuth	8 parts
Tin	4
Lead	5
Antimony	1

The metals should be repeatedly melted and poured into drops, until they are well mixed.

27. A block of wood is then turned into a shape similar to that of a button-die, into one end of which is worked a cavity, the size of the medal to be copied, and *not quite so deep* as its thickness; in this cavity the medal is placed; should it not fit tightly, a circle of paper is pressed in with it: the medal, being thus firmly mounted, is to be copied in the following manner :—

28. A sheet of smooth cartridge paper is fixed, by drawing pins or otherwise, withinside a box having sides about four inches high, which slope inwards in order to prevent the metal from being scattered away; the part to be used is very slightly oiled with a single drop of oil; on this is poured some of the prepared alloy, which should be removed from the fire as soon as melted. (§ 23.) The metal is then stirred together with cards until it assumes a pasty appearance, and is on the eve of crystallizing; if, at this stage, the surface should appear defaced with dross, one of the cards must be passed over it lightly and speedily; should no dross appear, this part of the process may be omitted. The die containing the medal, must then be held firmly in the right hand, and be struck gently and steadily upon the solidifying metal. Should an assistant be at hand to aid in this, it will be as well; for sometimes, during the brief interim, while the card is being exchanged for the die, the exact moment is lost,

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[*] *Vide Proceed.* Elec. Soc. part ii. p. 90, Aug. 17, 1841.

London:
Printed by Stewart and Mu
Old Bailey.

will now be ready for use, and is to be attached to a copper wire. The end of this wire must be *quite clean;* the wire is placed across the flame of the candle, with the clean end beyond the flame; it is to be touched with a piece of rosin, and pressed on the edge of the mould. The mould will instantly melt to receive it, and in a few seconds it will be cold and firmly fixed. The moulds should be wrapped in paper, if they are not intended for immediate use.

32. *Wax Moulds.*—The manipulation with this material is very simple. The wax employed is the common white wax, or the ends of wax candles. It is to be melted in an earthen pipkin or a small jug, and kept by the fire-side a few minutes after it is well melted. The medal to be copied should be made warm,—the warmer the better (the object being to prevent the sudden chill of the wax when poured on). It is to be surrounded with a rim, composed of a ribbon of paste-board. The end of this may conveniently be secured by a small *cleft* stick. The surface of the medal should be *very* slightly covered with olive oil. The hot wax is then poured on. It may require five or six hours to become sufficiently cold for removal; and great care must be taken to allow the cooling process to be gradual; for, without this precaution, the moulds, especially when of large objects, are apt to split. There will be at times a difficulty in removing wax moulds from medals with elaborate work. This may be obviated by a little care: the medal should be very slightly warmed by the heat of a candle, so as to cause a trifling expansion of the metal; and the wax is then to be drawn cautiously, and at right angles, from the surface of the medal. This applies to other composition moulds.

33. *Stearine Moulds,* &c.—From a few practical inconveniences attendant on the use of wax, I have at times preferred *stearine*, and consider it on the whole *very useful*, especially in copying works in metal; but *recent* experience has taught me that a still bett

material, is a composition consisting of 8 oz. c maceti to $1\frac{3}{4}$ oz. each of wax and mutton suet Rev. F. Lockey recommends a mixture of wax, st and *black-lead.* On this hint, I have added lead to some of my compositions, and with adv Since writing this paragraph, I have examine moulds made with wax and a little of what is *Flake-white,* and never saw any to equal them, not even the metal moulds.

34. That such compositions will produce minut rect copies of plaster casts renders them invaluabl electrotypist, who employs his scientific resour wards the formation of a collection of works of a he is thus enabled to transfer impressions from t and perishable *plaster* to the durable *copper ;* transfer them with all their beauty and all the fection. They who have obtained but a cas sight into the treasures transferred to this d but brittle material, have seen enough to them that there is an ample store to suit eve and every temper. For a few pence, specin first-rate execution may be obtained from any plaster shops in London;—they are often to be m in the hands of the Italian boys, who frequent the Care should be taken that the specimens selec free from defect. A few weeks' experience medals will be of more avail, in guiding the jud than pages of written instructions.

35. *To copy Plaster Casts.*—Pour some water into a plate ; stand the cast *face upw* this water : the water must not be deep enough t the *face* of the cast. In a few minutes, the cast filled with water.* Then, without loss of time round it a ribbon of pasteboard as before, (§. 3 *immediately* pour in the melted composition. becomes solid, let it remain for two or three

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* *The small* delicate casts, which are slightly tinted, *copied by* first moistening their surfaces with olive oil, *pouring* on the wax.

and the mould may *generally* be lifted off from the plaster, without further trouble.

36. This, however, is not always the case, for if the water, with which the plaster is soaked be too cool, or if the cast be not perfectly saturated, the wax will adhere; and even with every care, this will at times be found to occur, on account of imperfections in the structure of the cast. Unless the latter has been cast from good plaster very well mixed and stirred, it will be of a rotten texture and will readily break off in fragments after it has once been wetted; and these fragments will adhere to the mould. Having thus destroyed the cast, it is an object of some importance to preserve the mould by removing the fragments without affecting the wax surface. This is readily done by gently touching each spot of plaster with a wire dipped in sulphuric acid; and then leaving the cast exposed to the air for ten or twelve hours. The acid will gradually absorb moisture from the atmosphere, and their mutual action will so disintegrate the plaster, that it may be entirely washed away with a camel's hair brush and cold water. This simple process has been the means of effectually restoring to me many moulds, which otherwise would have been doomed to the same fate as the casts from which they had abstracted plaster.

37. *To render Wax or Composition Moulds Conductible.*—But wax and such like bodies are non-conductors; and as such will not be of any service to convey the voltaic current. In order to render their surface condutceous, many plans have been devised. There is one which combines the three advantages of simplicity, certainty, and economy. It is to cover the surface with black-lead; the application of this substance was recommended by Mr. Murray; it was also employed by Prof. Jacobi, and its management is described in his "GALVANO-PLASTIC."

38. This article is known in commerce under the several names of plumbago, graphite, and black-lead. The latter might naturally enough induce those unac-

quainted with the subject, to conclude that *lead* held a prominent place in its composition. This, however, is not the case; it contains no lead at all; it consists of carbon and iron;* the principal portion being *carbon*. This substance has been already mentioned; (§ 5.) it is a very good conductor. Plumbago is largely used in the arts: the finer sorts for drawing-pencils, the inferior in domestic economy, for polishing iron-work. It does not seem that the difference of quality in this substance depends entirely upon the quantity of carbon it contains. The common qualities, such as are used for polishing stoves, are very good conductors; and, if tolerably *pure*, will answer our purpose as well as the best among the finer specimens. Unfortunately, however, the common kinds of black-lead are largely adulterated: among the substances used for adulteration, are plaster of Paris and charcoal. The instrument makers, who sell the apparatus for Electrotype experiments, generally keep plumbago in a fit condition for applying to wax moulds.

39. It may be applied DRY. Having breathed slightly on the mould, dip a soft brush into the plumbago, and rub it briskly over the surface: continue this, breathing on it occasionally, till the whole presents the well-known black-lead polish. Be very careful to rub the brush into every spot. The best kind of brush is a strong and fine camel's hair pencil. With care this operation will not affect the sharpness of the mould in the slightest perceptible degree. When the mould seems to be covered, if, upon breathing on it, any parts appear *whitish*, repeat the operation.—In some cases the black lead may be applied wet, and afterwards polished.—Messrs. Elkingtons used the following mixture, instead of mere plumbago: Zinc is melted in an iron ladle until near the point of burning, when a few pieces of iron are dropped into it. When cold, *the mixture* is very friable. They reduce it to a fine *powder*, and mix it with plumbago, which they apply

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* *Its chemical name is carburet of iron.*

as before.—A clean wire slightly warmed, and pressed against the back of the mould, will become firmly imbedded in it. Then rub the wire and the wax about it with the plumbago brush, in order to complete the connection between the two. It is advisable to remove any plumbago which may have been spread on the edges of the mould, by scraping them with a knife. The mould is then ready for use, if *small;* but if *large,* the "guiding wires" recommended by Mr. Phillips, of St. Austell, may be occasionally added with advantage. One or more thin wires are twisted round the main wire, and their ends are allowed to rest against different parts of the mould, especially in the recesses of deep relief; and thus the copper is led to deposit over all parts of the surface in a short time. When this is effected, the guiding wires are carefully removed.—Sealing-wax impressions are coated with plumbago. To cause it to adhere, moisten the seal *slightly* with spirit of wine, or expose it to the vapour of ether. For delicate objects, as flowers, insects, &c., which cannot withstand the action of brushing, other modes must be adopted.—One method is to dip the article in a weak solution of nitrate of silver, and while moist to expose it to the vapour of phosphorus, under a tumbler or bell-glass. The vapour is procured by placing a watch glass, containing phosphorus dissolved in alcohol, in a saucer of hot sand. By this operation, the metal silver is reduced from its nitrate; and thus the surface of the article is made conducteous. This process has, in some cases, been adopted conjointly with the plumbago; on large objects, the black lead surface has been painted, first with nitrate of silver in solution, and then with the solution of phosphorus. The silver is sometimes reduced by the action of light; the same object has been also accomplished by allowing a jet of sulphurous acid gas to impinge on the surface moist with the *nitrate.*—The best preparation of phosphorus, *however, is its* solution in bisulphuret of carbon. *This highly* inflammable and very volatile compound greedily dissolves phosphorus; but about $\frac{1}{20}$th part of phosphorus will be found sufficient. The object is merely dipped in this; and, after a few seconds, is immersed for a short time in a weak solution of nitrate of silver, and then allowed to dry in the light. The greatest care must be exercised in these operations; for the articles themselves will often inflame spontaneously, if allowed to remain, after having been in the phosphorus solution;—it must not be dropped about; for, although apparently innocent at the moment, it may afterwards ignite, and cause very serious accidents, It must not be allowed to insinuate itself beneath the nails of the hand. A preparation of wax, containing a little of this solution, is sometimes used; it is melted, and the objects, when dipped in, need no further preparation.

40. *Plaster of Paris Moulds.*—Another mode of making moulds is with fine plaster. They are to be saturated with wax or tallow, by standing them in a shallow vessel containing these substances in a melted state, or they may have their surfaces covered with fine varnish, if the work will permit it; or they may be heated with hot boiled oil, containing a little bees' wax; and when cold they are to be coated with plumbago. (§ 34.) The best fine plaster should always be used; it should be *fresh:* if kept any time, it must be preserved from the air in jars or otherwise. In mixing, water is first poured into a lipped bason; the plaster is gradually dropped in, and the supernatant water poured away: the water which remains with the plaster is the proper proportion to be stirred with it: when well mixed, let a small quantity be brushed into all the work of the medal with a camel's-hair pencil; this removes air bubbles: then pour on the plaster to the thickness required. If the objects to be copied be lightly oiled first, little difficulty will be experienced in removing the plaster-mould when "set."—Fusible moulds will, with proper care, produce successively as many Electrotype copies as the operator pleases. Wax or composition moulds are mos

commonly damaged more or less, in removing the deposit.

41. When the object is undercut, the plaster mould may be made in pieces; and when put together in a mother-piece, the joinings must be modelled up. I have adopted this plan in some Electrotypes of Thorwalsden's "Triumph of Alexander;" in others, I have made the mould on the plaster cast, and have then broken the latter carefully away, so as to leave me a mould in a single piece. In either case, the mould requires to be broken away from the Electrotype.

42. *Elastic Moulds.*—Three parts of treacle are added to twelve parts of glue that has been carefully melted, and the whole is well incorporated. Metal and other objects, which would not "deliver" on ordinary moulds, on account of their high relief, may be readily moulded by this preparation, which will stretch during the removal of the mould, and will readily return to its original form.

III.—VOLTAIC APPARATUS TO BE USED.

43. The moulds thus prepared are fitted to fill the place of the negative or copper plate, in the generating[*] cell of a simple constant voltaic pair; (§ 17.) or of the negative plate in a decomposition[†] cell. In either case they occupy the place where hydrogen is evolved, if the liquid is acid water; (§ 4, 11.) and where copper is reduced, if this acid water contains sulphate of copper. (§ 12, 13, 18.)

44. For the simplest mode of obtaining an Electrotype medal, the reader is referred to the description given (§ 3.) of a single voltaic pair. Instead of using

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[*] This term is applied to that cell containing the single voltaic *pair of* zinc and copper, or other metal. (§ 3.)

[†] *This term* is applied to the second cell, into which the terminating wires (§ 11, 12, 13.) are brought.

the copper-plate as there described, attach (§ 31.) to the end of the wire one of the fusible moulds. (§ 24.) Bend the wire into the shape of the letter ∩, so that the mould shall face the zinc:—wrap the zinc in a piece of brown paper; pour within the paper some salt and water, or some water very slightly acidulated with sulphuric acid; and immerse the whole into a vessel containing a saturated (§ 18.) solution of sulphate of copper, having a little acid in it.

45. This apparatus will represent a single cell of a constant battery; (§ 17.) not constructed on the best principles, it is true, but sufficiently so for an introductory experiment. The copper of the solution will be released on the fusible mould: (§ 17.) after a few minutes' immersion the mould will be covered with a very brilliant coating of pure metallic copper;—after thirty hours, or less, with proper arrangements, (§ 58) this coating will be thick enough to remove:—when removed, it will present a perfect resemblance to the original medal.

46. *Amalgamation.*—To complete, however, the character of this constant voltaic pair, the zinc must be amalgamated; for besides the *electric* action upon common zinc, the acid acts on it *chemically*:—whether the former action be going on or not, the latter will not cease so long as there is any zinc to be acted upon, or any acid to act upon it. This arises from the quantity of foreign matter contained in the zinc of commerce:—this matter, which is mostly metallic, forms, with the particles of zinc, very many small voltaic pairs, all acting independently of the negative plate, (§ 3, 17.) and at the expense of the zinc and acid. *Pure* zinc, which may be obtained where Electrotype apparatus is sold, is not thus destroyed.

47. The process of amalgamation is this:—place some mercury in a saucer or plate; pour on it some *water* and sulphuric acid; brush the liquid and mercury over the surface of the zinc, till the whole is covered with a *bright* coat of mercury.

48. *Diaphragms.*—But the paper diaphragm above mentioned is very inconvenient in experiments of any duration; it seldom, perhaps never, prevents the partial mixing of the liquids it is designed to separate; and its use is always attended with a great waste of the sulphate of copper, the metal from which is released in great abundance, and deposited within the folds of the paper. The same may be said, though in a less degree, of animal membrane. Either will do very well for solitary experiments; but both are inconvenient, when the experiments are continued. Something more substantial and more durable is requisite. For this purpose porous tubes have been constructed of the material used for butter coolers: others have been made of pipe-clay. These are very capital diaphragms.

49. Very good diaphragms are easily made from plaster of Paris; and for this purpose the coarse plaster used by builders is best, care being taken to have it as *new and fresh* as possible: it is mixed with water in the usual way, (§ 40.) and is poured into a mould of the following construction:—A core is turned out of hard wood, nearly cylindrical, but a little smaller at one end, in order that it may draw out of the diaphragm when made; the thicker end has a shoulder rising a quarter of an inch or more beyond the surface of the core, according to the thickness required to be given. This, as well as the length and diameter of the core, will depend on the kind of diaphragm required. A thin sheet of tin or copper is now tied round the shoulder; and plaster being poured between the core and the envelope, a diaphragm is readily made. These diaphragms are very durable; and will be found a great acquisition to those who, from local circumstances, may not be able to obtain other kinds of porous ware. They are as good as *all* other diaphragms; *better than* a very large proportion; more economical *than any.*

50. *If*, in the introductory experiment alrea

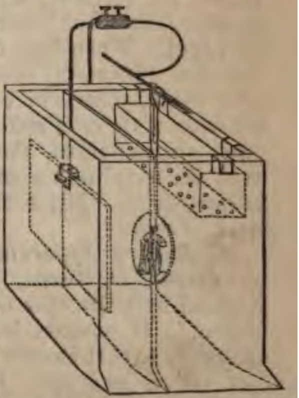
described, the amalgamated zinc and these diaphragms be employed, a constant battery is obtained, with all its parts complete. And if, in addition, a bag of crystals of sulphate of copper be hung in the blue solution, in order to recruit its strength, which is exhausted in proportion to the copper released; and the acid water around the zinc be occasionally renewed; the action may be continued for days or even weeks. And by removing the mould as soon as a sufficient thickness of copper is obtained, and supplying its place by another, three or four medals may be copied in a week.

51. *Single-cell Apparatus.*—The annexed woodcuts represent the single-cell apparatus in its complete form. Z is a rod of amalgamated zinc, *m* the mould, *w* the wire joining them, *C* the copper solution, *p* a tube of porous earthenware, containing a solution of acid and water. To put this in action, pour in the copper solution, fill the tube with the acid water, and place it as shown in the figure. *Last* (§ 75.) of all put in the bent wire, having the zinc at one end and the mould at the other. Another form of this apparatus is here given. The zinc is connected by a wire and binding screws with a metal rim; and on the latter can be hung several moulds, as in the drawing. Things are much more likely to go on well when several moulds, as thus, are operated on, than when only one is introduced. The reason will be manifest hereafter.

52. *The following precautions must be observed in using this apparatus.*—The copper solution must be *saturated*, or nearly so;—this is effected by keeping

the shelf well furnished with crystals. The mould must not be too small in proportion to the size of the zinc. The concentrated part of the solution must not be allowed to remain at the bottom. In the latter case, the copy will be irregular in thickness, —in the former, the metal may be a compact brittle mass; or may be deposited in a dull red, a violet, or a black powder. The nature of these several depositions will be elsewhere alluded to; (§ 62, &c.) so will also the relative proportions of the zinc, &c. (§ 78.)

53. *Single Cell without Acid or Mercury.*—The tyro must not imagine from the above descriptions that *acid* and *mercury* are the *sine quâ non* of success; because either of the above apparatus would be effective, though in a feeble degree, by charging the porous tube with a solution of sal-ammoniac, or even with one of common salt; and using zinc in its ordinary state; and employing a neutral solution of sulphate of copper. Sal-ammoniac, or hydro-chlorate of ammonia, consists of ammonia and muriatic acid. Its electro-chemical analysis is too complex to need a place here. Table salt, or chloride of sodium, consists of the gas, chlorine, and the metal, sodium: its action is, that the chlorine combines with the zinc, and forms the very soluble chloride of zinc; and the sodium combines with the oxygen, that would be nascent at the diaphragm, and forms soda. This arrangement is not so powerful as the other, because the sum of *the favourable*, minus the *unfavourable*, affinities is less in the one case than in *the other.*



54. A single cell apparatus may consist of a wooden box, well varnished in the interior, and divided into two unequal cells by a partition of porous wood. The wood is prepared as described above. (§ 17.) The larger cell is filled with a saturated solution of sulphate of copper, the smaller with a half-saturated solution of muriate of ammonia, or one of common salt. In the former is a shelf for containing a supply of crystals.

55. I do not recommend the use of the single cell arrangement, except for small objects; I do not adopt it on the large scale. Seals are electrotyped by the simplest form of the single cell: a warm wire is pressed into the edge of the seal, which is then covered with plumbago; the other end of the wire is twisted to a little piece of zinc, or even an iron nail, and the wire is bent ∩ fashion: a little diaphragm, of card sewed up, having the joinings secured with wax, is filled with water containing a pinch of salt, or a few drops of acid; this is placed in a tumbler of sulphate of copper; and the seal is immersed in the copper solution, while the other end of the wire, with its attached metal, is within the other liquid.—While upon seals, I may mention, that their electrotypes are easily backed up with lead. When fresh from the solution, let them be varnished with rosin, dissolved in ether, or otherwise; after which, there will be no difficulty in causing the adhesion of tin or of soft solder, when required. Under other circumstances, the best means of tinning is to wash the metal with a solution of chloride of zinc and sal-ammoniac. Mr. Lockey recommended stearine instead of rosin.

56. *Battery Apparatus.*—A valuable improvement was devised in Russia, by Professor Jacobi,* and in England by a Member of the Electrical Society, Mr. Mason.† It consists in using a decomposition cell, analogous to that already described. (§ 11.) The *constant voltaic* pair (§ 17.) of copper and zinc is used

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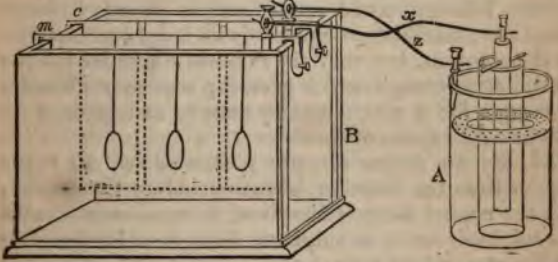
* *Vide* Jacobi's Galvano-Plastic.

† *Vide Proceedings* of the Electrical Society, April 1840, p. 203

as the generating cell. To the end of the wire attached to the copper is fastened a *plate of copper:* to the end of the wire attached to the zinc is affixed *the mould.* The sheet of copper and the mould are placed face to face in the decomposition cell. This arrangement will be better understood from the annexed figure. A is a cell of Daniell's Battery; (§ 17, 50.) B the decomposition cell, filled with the dilute acid solution of sulphate of copper; *c* the sheet of copper to furnish a supply; *m* the moulds to receive the deposite. To charge this, pour in the several solutions: hang a piece of copper on the brass rod *c*; connect this rod with the copper of the generating cell by the wire *z*; and the other rod *m*, with the zinc, by the wire *x*; *then*, and not *till* then, (§ 51.) hang the moulds on the rod *m*.



57. *Solutions.*—The solution used in this decomposition cell or depositing trough greatly depends on the battery or power employed; with a cell of Daniell's Constant Battery, a solution of about 2 sulphate of copper by measure, and 1 acid water (1 acid + 9 water) is undoubtedly the best. When less power is employed, a little acid in addition is found to be advantageous.

Professor von Kobell, instead of mixing acid water with the saturated solution of sulphate of copper, adds *solutions of* Glauber's salt, or of potash alum, or of *nitrate of* potash; by which means he obtains deposits *of very* malleable copper. Glauber's salt appears to the best; it renders the solution more conductible, and is not itself decomposed by such feeble currents, as are here in use; while its solution will take up as much sulphate of copper as common water does. Two of saturated solution of sulphate of copper, and one of sulphate of copper in solution of Glauber's salt, are stated to be good proportions.

To the ordinary solution of sulphate of copper, Messrs. Elkingtons add caustic potash or soda in small quantities, until the precipitate is no longer redissolved by the solution, and they thus obtain a solution for the precipitating trough which gives up a greater quantity of copper for a given battery action, and gives it up also in a less space of time.

58. By an action already illustrated, (§ 13.) the copper from the solution is transferred to the mould; and the copper sheet is dissolved, being converted with the sulphuric acid into sulphate of copper; thus keeping up the strength of the solution. The time is somewhat longer by this method: two days will produce a medal of very good substance, firm and *pliable*. In speaking, however, of the *time* required for these experiments, it must be borne in mind that this depends much on the *temperature*. If the solutions are kept boiling, a medal may be made in a few hours. A single-cell apparatus can be readily treated thus; contrivances may easily be devised for applying the heat from a furnace or a spirit lamp. In severe weather, the action of the battery almost ceases. During the severe winter of 1840-41, from November to March, my batteries were placed within a few yards of the fire.

51. The advantages derived from the introduction of a decomposition cell are not limited to the production of single copies. Two or more may be made without any further consumption of material in the battery. If, for instance, two cells be placed side by side, an *the plate of* copper (§ 56.) be placed in one, and the *mould (§ 56.)* in the other: then, if the two cells be *connected* by means of a bent copper wire, dipping int

the liquid of each, a circuit will be completed for the passage of the voltaic current. In *one* cell, the copper plate will be dissolved as before; (§ 58.) and copper will be deposited on one end of the bent wire: in the *other* cell, the end of that wire will be dissolved, and copper will be deposited on the mould. If the bent wire is removed, and a *mould* is fixed (§ 31.) on one end of it to receive the copper released in the *first* cell, and a plate of copper* on the other end to furnish a supply in the *second* cell, the *one* action of the battery will produce *two* medals.

60. This mode of proceeding is not confined to taking merely *two* copies at a time; it may be extended much further by using more cells. Experience has taught me that *six* is the most convenient number. The cells are to be connected, each to each, by bent wires, having a mould on one end and a piece of *copper* on the other. In proportion to the number of cells used, the *strength* of the solution (§ 57.) in them must be reduced by adding water, and its *conductibility* increased by adding acid. It is desirable to place the moulds and the sheets of copper as near together as possible, taking care that they do not *touch*. A single pair of copper and zinc in the battery or generating cell (§ 56.) will thus produce a series of *six* medals in three days, if the temperature is not much below sixty.

61. They who possess the earthenware troughs belonging to the Wollaston battery will find the cells, on account of their shape, very convenient for this purpose. These troughs commonly contain twelve cells: I have been in the habit of connecting six with one battery, and six with another; and producing, by the use of one trough, two dozen electrotype medals per week. The *shape* of these cells permits the moulds and copper plates to be placed face to face, which, with other

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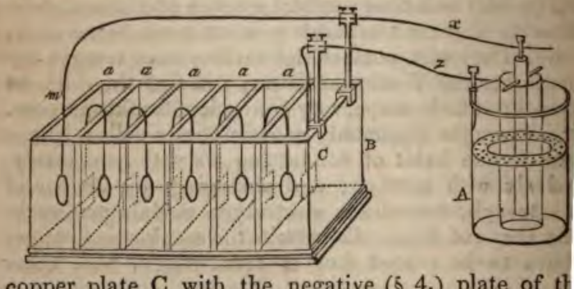
* Soldering is not necessary for this purpose; let a hole be punched *in the copper*, and the wire be passed through and twisted. It is then *as well to* varnish the wire (§ 31.) to protect it. Wires may be *united by* binding screws, cleft sticks, or twisting.

precautions, insures an *even* deposite;—and near to each other, which shortens the length of liquid to be passed through, and thus facilitates the operation. The metal obtained by thus placing the moulds in series is of the best description. Troughs, for this purpose, may be made in well-varnished wood, of various sizes, and be divided into six cells, by means of plate glass or glazed porcelain partitions.

62. The advantage of this mode, in point of economy, will be manifest, when it is remembered that for every *ounce* of copper released from the solution in the generating cell, an *ounce* will be deposited on *each* mould (page 20); and about an *ounce* of zinc will be consumed in effecting this. Whether, therefore, one, (§ 56.) or six, (§ 60.) or even twenty moulds be placed in series, the *same quantity* of *zinc* will be required. Hence an ounce of zinc may be made to furnish electricity enough to produce, according to the will of the experimenter, one, or six, or more medals, *each* weighing an ounce.

63. *Battery Apparatus extended.*—Annexed is an engraving of a Daniell's battery, thus connected with a series of six cells, in each of which is a mould. A, the battery; B, the trough; *z*, wire connecting



copper plate C with the negative (§ 4.) plate of t
battery; x, wire connecting mould *m* with the zinc
battery; a, a, a, a, a, five bent wires, each havi
a mould at one end and a piece of copper at the oth

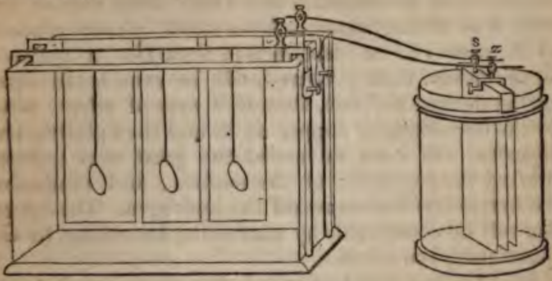
(§ 31.) A little management is requisite in charging this, in order to preserve the bright surface (§ 51.) of the medals produced.—Charge the battery as elsewhere directed; connect the copper-plate C with the battery;—place a *wire* with its extreme ends dipping in the *extreme* cells of the trough; then, having previously connected the zinc and mould with the wire *x*, place the zinc in the porous cell and the mould in its place at *m;* in about two minutes, it will be covered with copper; after this, there is no fear of chemical (§ 60.) action; then remove the end of the copper wire from the cell containing *m*, and place it in the next cell;—complete the circuit with the bent wire *a*, having a mould at one end, and a sheet of copper at the other; after waiting a minute or two for a deposite of copper, remove the end of the wire one cell further forward; and so continue till the six moulds are placed in.

64. I have been in the habit of rendering the Electrotype art available in the production of the very apparatus which is destined to be employed in the art; and have produced a compact, neat, and very simple *battery*, by the same process by which the battery thus formed will produce copies of medals. I take a large jelly-pot, and placing within it some wax, stand it by the fire, till the wax is melted, and the vessel thoroughly heated; then turn it about, so that the wax shall spread over every part of the interior: and having done this, pour away the superfluous wax. When cold, I rub plumbago, in the manner formerly described, (§38.) over the wax adhering to the *sides*. This vessel is then filled with a saturated acid solution of sulphate of copper, and in it is placed a porous tube; the tube is filled with acid water; a piece of amalgamated zinc is placed in the tube; the wire, attached to it, is bent over, and made to press upon the surface of the plumbago. In two or three hours, the whole of the interior where *the* plumbago is, will be covered with metallic *copper*. The vessel will now form one of the best and

simplest generating or battery cells that can be constructed: this deposition of copper forms the copper-plate, (§ 3.) of the voltaic pair. The plaster diaphragm (§ 49.) and the solutions will complete the apparatus. Or the *whole* of the interior surface might be covered with plumbago; and when, after having been used for a week or two, the deposited copper should become thick enough, it might be drawn out, or the earthenware cell might be broken from it, and thus a complete cell of a Daniell's battery (§ 56.) might be obtained without a seam or join. To connect a wire with this coating, it is only necessary to brighten the end, and bend it so that it shall press closely.

65. *Smee's Battery.*—This very useful source of voltaic power was named by its inventor, the *Chemico-mechanical* Battery. It requires but one liquid for exciting it, namely, acid water; the metals are amalgamated zinc and platinized silver,—that is, silver on which molecules of platinum have been voltaically deposited in the form of a black powder.—A small quantity of the bichloride of platinum is mixed with acid water, and the solution is decomposed by the use of a platinum terminal in connection with the *copper* of the battery, and the substance to be platinized in connection with the *zinc*. A few minutes' action will suffice. Platinum is sometimes platinized; but, for all practical purposes, silver is equally serviceable. This aggregation of small points facilitates the liberation of the evolved hydrogen, which escapes with a loud hissing noise, in place of adhering to the metal and interrupting the action. The arrangement is generally made with one platinized silver plate between two zinc plates, as in the following figure, where *s* is the silver plate connected with the copper of the usual decomposition cell, and *z* the zinc plate connected with the moulds. In employing this arrangement, care must be *taken to* avoid dropping any sulphate of copper into *the* acid water; for the copper would at once

reduced upon the silver plate, and alter the nature of the battery.



66. As the silver plate in this arrangement is between the zinc plates, it follows that the streams of hydrogen must *ascend* between the metals of the pair, so that, while in one sense they form a partial screen between the plates, they, on the other hand, prevent the plates being approximated within certain limits. A very ingenious modification of this arrangement has been devised by Professor Grove,* who substitutes platinized *silver gauze* in place of the *plate of silver;* as, by this means a facility is afforded to the hydrogen of passing through the apertures of the gauze, and making its escape at the *outer* side instead of *between* the two plates, the latter may be brought much closer together, without having the action intercepted by the presence of the liberated and escaping hydrogen.

67. *New Electrotype Battery.*—As it is no easy matter to obtain silver gauze, I advise the following substitute, which has its peculiar advantages:—Take a sheet of cleaned (§ 98.) copper gauze, of the *exact* size required, (for it must not be cut afterwards,) and affix to it permanently the binding screw or wire, which is to be employed afterwards in making connections. Place it then *in* a decomposition cell, containing sulphate of *copper,* and submit each side to the action of the bat-

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* *Vide* Proceed. Elec. Soc. p. 117.—Sept. 21, 1841.

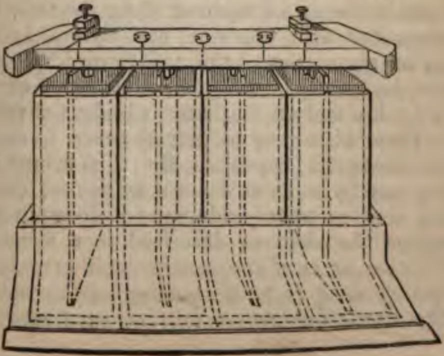
tery, until a bright deposite of *pure copper* is thrown down, of sufficient thickness to coat all the wires, and to unite them permanently into one. Then remove and wash it in boiling water. After which, *electro-plate* it by the means to be described in Part II. A piece of *copper* gauze, thus prepared, will be even better fitted for the desired purpose, than if it were of *silver* wire; for the deposition of copper on it, and then plating this deposite, will have advanced one great step towards altering the character of the surface; and producing one better fitted to throw off the hydrogen. The operation will be completed, by platinizing according to the directions given above.

68. In the illustration of the platinized battery, (§ 65.) the metals are represented *parallel* and *perpendicular;* in the present arrangement there must be but one zinc plate, and the zinc and gauze must be *very near to each other*, but must *deviate* a few degrees *from the perpendicular;* and in such a direction that the platinized gauze shall be, as it were, *uppermost.* For, as the gas finds its way to the surface in perpendicular lines, such a disposition of the arrangement will at once admit it to pass through the interstices of the gauze, and readily to escape by the desired channel, —the outside of the gauze. A better mode of constructing the apparatus is to employ a gauze on each side of the zinc. In this case, the zinc must be perpendicular; and the gauze not *exactly* parallel, but rather *closer* at the top than below. The difficulty of obtaining copper gauze led to the production of electro-lace, which was first suggested and made for this kind of battery by Mr. Phillips of St. Austell.

69. *Electro-Lace.*—A piece of lace is stretched on a frame, and well rubbed with warm wax: it is then held to the fire to effect its saturation with wax, and is placed afterwards, and while hot, between two pieces of *blotting* paper in order to remove the wax from the *pattern;* or it may be saturated with varnish. It is *then plumbagoed* and treated as an ordinary mould. *A few hours'* action will so deposite metal on it as

resent the character of a perfect conversion into coper. This may be plated, and then platinized.

70. *Constant Acid Battery.*—Since the appearance f the *first edition* of this work, I have been employg, with slight modification, an ordinary *acid* battery, amely, a chemico-mechanical battery, in which roughned copper is used instead of platinized silver; and I nd it admirably adapted to the purpose of Electroype. Other circumstances being the same, it requires early *twice* the time of a sulphate battery: but this is a degree compensated by the fineness of the deposite btained, and the trifling expense attending its use.—he interior of a jar is coated with copper, (§ 67.) and e action is continued until the solution employed for is purpose is nearly exhausted. By this means, the rface of the copper obtained presents an infinite umber of small points, which very readily part with the ydrogen. The principle is precisely that developed y Mr. Smee, and brought to practice in his platinized attery.—This arrangement may be adopted without e use of diaphragms. Amalgamated zinc is emloyed. I find that this kind of battery, variously rranged, is greatly used in the arts. Sometimes a ingle battery is sufficient; at other times, a series of wo, three, or four, having the zinc of one connected ith the copper of the next; as in this engraving.—



I have myself been of late operating with this battery on a large scale, using surfaces of from 10 to 14 square feet:—if the copper surface has been exposed to the air for any time, while the battery is out of use, it should be well washed with acid water, or the old solution of zinc, before using it again, in order to remove any oxide of copper that may be there. Under these circumstances, I have every reason to be satisfied with its action, and to prefer it, from its simplicity and steady action, to any other form.

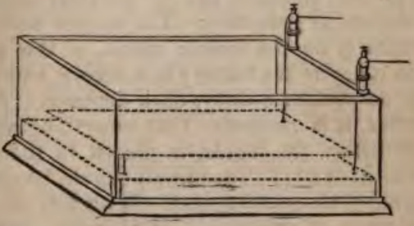
71. *Prince Bagration's Battery.*—A pan is filled with earth, which is then saturated with a solution of sal-ammoniac: a copper plate, having been first wetted with solution of sal-ammoniac, and then exposed to the air until a green film is formed, is thrust into the pan of earth; and opposite to it is thrust a zinc plate. Prof. Jacobi speaks favourably of this source of a constant power for the reduction of metals.

72. *The Earth a Battery.*—When slow actions are required, the earth itself may be made a source of power; all that is necessary being to bury in it large plates of zinc and copper. The native moisture of the soil constitutes the exciting liquid.

73. *Decomposition Cells* may be constructed of all sizes, according to circumstances, of wood, protected with varnish, or other compounds impervious to water. Two parallel wires are secured along the top; one is to be connected with the zinc, and the other with the copper of the battery. On the former are hung the moulds, by merely bending the wires attached to them, into a hook; and on the latter is hung a sheet of copper. These wires may be placed nearer to each other, as circumstances require. By this means, several medals may be made at the same time. This arrangement is most commonly adopted: it does not of course *economise* the zinc, as described in a former place. (§ 62.) One ounce of zinc produces six or more medals, *not weighing each*, but *all* together an ounce.

74. The deposited metal will present various thick-

es, according to the relative position of the mould
the plate of copper; if they are face to face, and
llel, the thickness will be uniform or nearly so;
rally speaking, the copper on the lower part of the
ld is thicker than that on the higher: this occurs
the specific gravity of the sulphuric acid, used to
ler the liquid conductible, determining it in a mea-
toward the bottom of the cell, rendering the lower
of the liquid more conductible than the upper.
ause a more uniform distribution, it is better to stir
liquid occasionally. But in many cases it is ad-
ble to have a flat trough, as in the annexed sketch,



to place the mould below and the copper plate
ve. With large casts, and those in deep relief, this
bsolutely necessary; for without it a uniform thick-
in the deposite is next to impossible, and the solu-
within the recesses of the mould, being unable to
nd and interchange itself with the rest, as it be-
es exhausted of metal, soon gives a brittle deposite,
finally no deposite at all. My largest trough,
ch will contain upwards of a hundred gallons of
tion, is of this form, and is lined with a mixture of
halte and rosin. Mechanical arrangements keep
mould sunk, until the deposited metal is itself
vy enough for the purpose. The copper plate is
oved once or twice a day and washed, to prevent
ling the cast with the impurities of the metal.

order to hasten the thickening of the deposite
essor Jacobi has recommended that copper filin

be occasionally sifted upon the Electrotype; and when one batch of filings have become incorporated with the solid metal, by means of the reduced copper, he advises other siftings to be made: and so on.

75. *Management of the Moulds.*—Thus much, then, with respect to the construction of moulds, and the nature and various forms of the voltaic apparatus. From what has been said, the reader will be able to make his own selection, according to circumstances; he will see the capabilities of the several processes, and adopt the one best suited to his particular purpose. It remains now to give a few special directions in reference to the management of moulds, and of the voltaic apparatus generally. The copper solution will act *chemically* on the fusible metal, if the mould is placed in it before the battery is in action, and will produce on its surface a dirty, dark deposite. To guard against this, it is necessary that everything should be arranged before the mould is placed in the situation allotted to it. (§ 51.) The circuit should be completed by immersing the mould *last.* With this precaution, the immersion of the mould, if of metal, will be followed by an *instant* deposite of copper on its *whole* surface; after which there is no fear of the oxide. A circumstance no less strange than true in these experiments, is, that the surface of a fusible mould thus managed is never *wetted* by the liquid in which it is placed; in fact, it never comes into *actual contact* with the liquid; its immersion in the liquid and its receiving a coating of copper are *simultaneous;* the one is the *instantaneous* cause of the other. When the copy is removed, the mould is as *bright* and as *dry* as when first made.

76. The deposition of the copper on the plumbagoed surface (§ 39.) of the wax moulds, is not thus *instantaneous.* The film of conducting substance with which they are coated being very thin, and not continuous, the operation is a step by step process from particle to particle. The deposition of copper is gradual:

it commences in the neighbourhood of the wire attached to them, and spreads gradually over the remaining portion. These moulds *do* become *wetted*, and the medals obtained from them often come off with dirty surfaces; the medals also bring with them the whole or part of the plumbago, and hence the moulds, if not damaged, require a fresh coat of this, before they are used again. These dirty specimens may be very readily cleaned, if required; the mode will be described in the sequel. The production of dirty medals is the least evil arising from the use of plumbagoed moulds; there is one of far greater importance—one which requires some attention to escape. As the deposition of copper, which is *gradually* diffused over the whole surface, *commences* at one point contiguous to the connecting wire, it follows that the power of the battery at the first is concentrated in a *small* space. The consequence of this will be, that, unless means be taken to avert it, hydrogen will be evolved with the copper *at first*, decreasing in quantity till enough of the mould is covered with a film of copper to increase the size of the surface to the requisite standard for releasing *copper alone:* after this all things go on well; but it is invariably found that the portion near the wire, from the irregularity of the primitive deposite, is *rotten* or very brittle. To prevent this, I always *begin* by placing a *wire* in lieu of a *plate*, opposite the plumbagoed mould, in the decomposition cell; this reduces the power of the battery or the quantity of electricity passing:—as the copper deposites, I immerse the wire to a greater depth, and when the mould is partially covered with copper, I remove the *wire*, place in the copper *plate*, and leave the experiment with the assurance of a successful result. But moulds furnished with guiding wires (§ 39.) may be put into the decomposition cell without the precaution of using a *wire* first, instead of a *plate*, as above *suggested*.—It will occasionally occur in wax moulds and sometimes in fusible metal moulds of very elaborately executed medals, that bubbles of air remain in some of the complicated interstices; these must be removed, or the result will be infallibly disfigured. They are removed by lightly brushing the surface of the mould with a feather, *immediately* after it is immersed in the liquid. If it should seem that any part of the mould is not sufficiently coated with plumbago, it may be removed from the solution, washed with water, dried with blotting-paper, and again rubbed with plumbago. This will sometimes save it, although generally such a condition of things announces a failure.

77. *Management of the Battery Apparatus.*—The Electro-typist, who expects to find *all* his experiments going on favourably, will be often grievously disappointed: with the best intentions and the most careful arrangements he may *sometimes* fail. For, after having observed *all* the directions hitherto given, his battery may have *too little* work to do, or *too much;* and this can only be determined by experience, and by attention to the principles laid down in this book. The former will produce the *dark powder*, elsewhere mentioned (§ 76.); the latter a hard, *red, brittle* deposite, or a heap of crystals. The terms *too much* and *too little* are here used in a very general sense, and will be better understood by describing the *causes*, the *results*, and the *mode of rectifying* these irregularities.

78. If the battery is *too large*, or the copper plate in the decomposition cell is *too large;* or if the mould is *too small*, *hydrogen* as well as copper will be released, and the deposite will be the *dark powder:* the same will occur if the solution in the decomposition cell contains too *much* acid or too *little* sulphate of copper. To rectify this, the battery may be made *smaller* by pouring out some of the solution, and so exciting less of its surface; or a smaller copper plate *may be* used in the decomposition cell; or crystals of *sulphate of* copper may be thrown into the liquid contained therein; or the copper plate and mould may be

removed *far* apart; or a *fine* wire may be interposed between the mould and the wire connecting it with the battery. Each or all of these alterations may be made according as circumstances or convenience shall dictate; a few days' experience will be better than pages of instruction.

79. If the battery is *too small*, or the copper plate in the decomposition cell *too small;* or if the mould is too *large*, or if the decomposition cell contains too *little* acid or too *much* sulphate of copper, or if the weather be too *cold*, the copper will be deposited *very* slowly, and will present a dull red exterior, and be of a very brittle texture; or will be thrown down in a crystalline form. The alterations necessary to rectify this defect will readily suggest themselves.

80. The medium between these two conditions fortunately has a very wide range, so that the chances of avoiding the two extremes are greatly in favour of the experimenter. The lines of demarcation within which the proper deposite is obtained, are, as may be imagined, not precisely defined. And hence the deposited metal possesses various gradations of character, according to the circumstances under which it is obtained. When all things are going on well, if the mould be lifted out* of the solution, it will present a *brilliant, light, copper-coloured* surface; this characteristic can scarcely be mistaken after it is once seen.

81. In addition to this, the following general observations on the theory of the deposites, may be acceptable:—" It was thought that the rotten deposite —a characteristic with which all those who are but just initiated into the art are familiar—results from the presence of the sulphate of zinc among the sulphate of copper. . . . The real cause depends on the relation subsisting between the generating power, dependent on the action between the zinc and the acid, and the strength of the solution of the sulphate of copper, on

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* *The mould may be removed with impunity, after it is well coated with metal.*

which this power is exercised. If the latter is *well* saturated, the copper will be released pure and firm; if it is almost exhausted, the hydrogen gas will be released with the copper, and the deposite will be a dull *powder*. In the wide range between these two states is found the brittle deposite: it appears under many varieties of forms, according as the solution is nearer to a state of saturation or to one of exhaustion on the one hand; or according to the energy or weakness of the affinity between the zinc and its exciting solution on the other. This latter condition exists in a modified form, when a *large* piece of zinc is used with a *small* object to be copied. The deposite is very *hard*, but not tenacious. It may be easily broken. In copying seals, and such like small objects, little pieces of zinc an inch square are quite large enough."

82. The medals are removed from the *fusible* moulds by gradually raising the edges with a pointed instrument, a brad-awl, for instance, and then using it lever-fashion to raise the medal out of the mould. Care must be exercised in this, for the contact between the two is so close that the force occasionally required may cut the medallion. The separation from the *wax-moulds* requires no force, they are laid face downwards on a table, and after pressing the slight over-lapping edge of copper with the brad-awl, in different parts of the circumference, the two may be pulled apart.

IV.—Bronzing.

83. If proper precautions are taken, the medals from the fusible moulds will *generally* present a bright *copper* surface; occasionally, however, they will present a very *brilliant* surface, greatly resembling *silver*. When this is the case they are ready, without *further* trouble, for the cabinet. The silvery tint is *only* obtained on *first* specimens: it would seem that the surface of the *new-made* mould is covered with a

metallic film, which attaches itself *firmly* to the surface of the deposited copper. It is so firmly attached, that it may be polished with a leather, or plate-brush, without sensibly affecting it. If specimens of this description are exposed to the air, they will occasionally require the application of the plate-brush to restore their primitive brilliancy.

84. *Chemical Bronze.*—There are many modes of bronzing employed in the arts, the intent of each is to bring out the workmanship of the object. The selection is entirely a matter of taste. To prevent too great a sameness of appearance in a cabinet, it is perhaps better not to confine oneself to a solitary method. —A *chemical* bronze may be made by boiling two ounces of carbonate of ammonia with one ounce of acetate of copper in half a pint of vinegar, till the vinegar is nearly evaporated. Into this, pour a solution consisting of sixty-two grains of muriate of ammonia, and fifteen grains and a half of oxalic acid, in half a pint of vinegar. Replace the vessel on the fire till the contents boil; when cold, strain through filtering paper; preserve the liquor for use. The remaining sediment may be again treated with another half pint of the solution. This preparation must only be applied to medals perfectly *bright* and *clean.*

85. Dirty specimens may be polished by an article used in domestic economy, consisting of rottenstone, soft soap, and water; the medal is to be well rubbed with a hard brush dipped in this. Care must be taken not to scratch the medal. It must afterwards be washed in water and placed to dry; when dry, the application of the leather and plate-brush will produce the required polish. Medals may also be cleaned by dipping them for a few seconds in nitric acid, either concentrated or diluted; wax and grease may be removed by boiling in pearl-ash and water, or by pouring *the boiling* ley on the medals; or by washing with *turpentine.* Cleansing processes will be more fully *described* in the Second Part, when we come to ele

tro-gilding and plating, in which they are of prime importance.

86. In applying the bronze, first warm the medal, then dip a camel's hair pencil into the liquor, (§ 84.) and brush the surface for *half a minute; immediately* after, pour *boiling* water over it; *directly* the medal is *dry*, rub its surface lightly with soft cotton, *very* slightly moistened in linseed oil: gentle friction with a piece of dry cotton will finish the operation. The colour produced by this means, is red; its tint varies according to circumstances. Medals bronzed thus must be examined occasionally before they are consigned to the cabinet; for if perchance the vinegar has not been *perfectly* washed away, they will be disfigured by the formation of a green powder,—the acetate of copper. Should this occur, it may be removed by means of the moist and dry cotton.

87. *Black Lead Bronze.*—A very beautiful bronze is obtained by the simple application of plumbago; it is obtained in a few minutes, and with very little trouble. The tint obtained seems very much to depend on the condition of the *surface* of the *original medal;* copies of some medals 'take' the black lead better than those of others. To produce the tint in the greatest perfection, the operation should be performed *immediately* after the medal is separated from the mould. *Bright* specimens from *fusible* moulds are best, but all others may be thus treated; those taken from wax should be cleaned with pearl-ash or soda.

88. The bronze is obtained by brushing the surface of the medal with plumbago; then placing it on a clear fire till it is made too hot to be touched, and applying a plate-brush, as soon as it ceases to be hot enough to burn the brush. A few strokes of the brush will produce a dark brown polish, approaching black, *but entirely* distinct from the well-known appearance of *black lead.* If the same operation is performed on a *medal that* has been kept some days, or upon one that *has been* polished, (§ 85.) a different but very brillian

tint is produced. The colour is between red and brown. The richness of colour thus produced, is by many preferred to the true dark brown.

89. *Carbonate of Iron Bronze.*—Very beautiful tints are produced by using the substance commonly known as plate-powder, or rouge; after moistening it with water it is applied and treated precisely in the same manner as the plumbago. Some care and practice are required in its use, lest it should *stain* instead of *bronze* the medal.—I have received from the publishers of this book a specimen of bronze superior to any I have elsewhere met with. It leaves nothing to be desired. —Should an experiment fail, the several bronzes may, in many cases, be removed, and the attempt can be repeated.

90. *Mounting the Medals.* — I have adopted a method of mounting the medals obtained from the *fusible* moulds, (§ 20.) which gives a finish to their appearance. I obtain pale green cards, the size of visiting cards; and cut some of these into single squares; *the width* of the card being the side of the square; others into smaller squares, *half the length* of the card forming the side of the square. A pencil circle is drawn the size of the medal; and two *ink* circles in order to 'throw' the medal 'forward.' The part within the pencil circle is cut out; and waste cards are cut to fit the extra edge of the medal. The two cards being fixed together with very strong gum water, the medal is placed in, and secured by another card gummed on at the back. The obverse and reverse are then gummed back to back, and thus the appearance of a perfect and solid medal is produced, equal, in point of workmanship and beauty, to the original. To hold the cards together until the gum dries, I use cleft-sticks. The medals obtained from wax moulds, having no addition to the edges, are not well fitted to be mounted thus: they may simply have any roughness removed from their edges with a sharp file, and be placed in the cabinet without being fitted with cards.

V.—Concluding Observations.

9 . Having now gone systematically through the process of working in copper, by means of the voltaic current, halting here and stepping aside there, in order to make all things as clear as possible; and having fulfilled my promise (§ 1.) of leading the reader "from the original medal to the perfect copy, ready for the cabinet;" I trust he is in a condition, so far as these instructions are concerned, to go from small things to great, and by increasing the size of his apparatus, as it shall seem good to him, to carry out on the large scale what he has here been taught to do on the small. I now, therefore, refer him to Part II., in which the manipulation with gold and silver, and other metals and alloys of metals, will be detailed; and all and sundry the leading applications and the extensive ramifications of the art will be set before him.

END OF PART 1.

INDEX.

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ELECTROTYPE MANIPULATION:

PART II.

CONTAINING
THE THEORY AND PLAIN INSTRUCTIONS
IN THE ARTS OF
ELECTRO-PLATING, ELECTRO-GILDING,
AND
ELECTRO-ETCHING;
WITH AN ACCOUNT OF
THE MODE OF DEPOSITING METALLIC OXIDES,
AND OF THE SEVERAL
APPLICATIONS OF ELECTROTYPE IN THE ARTS.

BY
CHARLES V. WALKER,
HONORARY SECRETARY TO THE LONDON ELECTRICAL SOCIETY;
EDITOR OF THE ELECTRICAL MAGAZINE, KAEMTZ'S METEOROLOGY, &c.

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I.—INTRODUCTORY OBSERVATIONS.

II.—Deposition of the Oxides of Metals on Metals.

III.—Electro-Etching.

IV.—Applications of Electrotype, &c.

ELECTROTYPE MANIPULATION

PART II.

I. INTRODUCTORY OBSERVATIONS.

92. Having in PART I. given the mode of working in copper, we pass on now to other metals. First in importance come gold and silver. The earliest experiments in electro-gilding were those by Brugnatelli, who gilded silver medals by electricity, in 1805; he used a solution of nitro-muriate of gold mixed with a solution of ammonia. The next were those of De la Rive, in 1841, who used a solution of chloride of gold. But these processes were interesting rather in a theoretical than in a practical point of view; inasmuch as the elective chemical affinity of the elements (combined in these solutions with the gold) for the baser metals, which might be immersed in the solutions, is such, that a violent interchange of elements takes place, and the gold is set free without even electric agency; and the solutions are so readily decomposed by the smallest adventitious aid, that it is a practical impossibility to obtain a "reguline" deposit, however much the voltaic power may be modified.

The same observations apply to the ordinary salts of silver, as, for example, the nitrate, &c. In fact, lon efore the theory of chemical deposites was understo made some experiments upon the electrolysis of alt, and succeeded in producing an electrotype me with a *silver* surface being I think the *first* insta of electro-plating, when the *object of the experiment was electro-plating*. But I was unsuccessful in my ttempts to repeat the experiments; and simply because, in that instance, I *chanced* to have in action power nicely *balanced* with the work to be performed, but in future instances my power was not adjusted to the work.

93. The first practical process for working in these noble metals, is, undoubtedly, due to the patentees, Messrs. Elkington. Others have laid claim to having been the first to use solutions similar to theirs; but whatever may have been done by these others in private, it does not appear that the public were in possession of their processes by any authentic publication; and therefore, there is no alternative but to give the patentees the claim of originality and priority.

94. The solutions they employ are the *argento-cyanide* and the *auro-cyanide* of potassium; upon which compounds it will be well if we make a few observations here, at the outset. They are what the chemists term double salts, as for instance, *cyanide of potassium* is a compound simply of potassium and cyanogen; *argento-cyanide of potassium* is silver and cyanogen combined with potassium and cyanogen, or, which amounts to the same thing, cyanide of silver united with cyanide of potassium.

When viewing (§ 13.) what happened during the decomposition of sulphate of copper, we had occasion to describe that body as *oxide of copper*, dissolved in, or combined with *sulphuric acid*: now, oxide of copper is 1 part copper + 1 part oxygen, and sulphuric acid is 1 part sulphur + 3 parts oxygen, and a certain *quantity of* water; so that, altogether, the arrangement is somewhat complex. This is not so much the case with the bodies now in question; and first, in respect to the simple *cyanide of potassium*, before it is united with the gold or silver. It consists simply of one equivalent of the metal potassium, and one equivalent of cyanogen; and, when it is acted upon by a voltaic current, in the usual way, it is decomposed by *direct* action, and cyanogen is liberated at the one pole, and potassium is *determined* to the other, but not *liberated.* It will be remembered (§ 13.) that, in the solution of sulphate of copper, *water* was decomposed by the *direct* action, and that the copper was liberated by a *secondary* action, namely, by the hydrogen of the water returning back into solution in the place of the copper. Well; the cyanide of potassium is decomposed by *direct* action, and potassium is presented to the negative metal; but a *secondary* action now occurs: so great is the affinity of potassium for oxygen, that it cannot exist in a metallic form in presence of that element; as is well known from the common experiment of dropping a piece of potassium upon water, when it combines so violently with the oxygen as to produce heat and light; and the resulting products are oxide of potassium, the common *caustic potash*, accompanied with a liberation of hydrogen. So, also, in the present case; the potassium does not itself appear, but, in its place, we find hydrogen and potash; it takes oxygen from the water and forms potash, and sets the hydrogen free. It is true, we are in possession of a means of preventing its return into solution, and this is by employing a mass of mercury to receive it: in which case it unites with the mercury and forms the amalgam of potassium; and neither hydrogen nor potash are manifested; but it will remain thus only under favourable circumstances; for if the connections with the battery are broken, so that *the mercury* ceases to be negatively electrified, the *potassium* immediately leaves it, and decomposes the water as before. Thus much in reference to the simp cyanide of potassium. Of the double cyanides, t argento may be taken as an example. It consists o 1 part cyanide of potassium and 1 part cyanide o silver,—the latter cyanide, like the former, consistin of 1 part metal + 1 cyanogen. When a solution o this double cyanide is electrolyzed, silver appears a one pole, and cyanogen at the other. But, in order t the production of this result, it is absolutely essentia that there be a considerable surplus quantity of th cyanide of potassium in solution; indeed, it is prett evident that the direct action is the decomposition o the surplus cyanide, and that the silver is reduced b secondary action in the following way: when th metal potassium is reduced from its cyanide, it return into solution, and takes the place of the silver in th double salt, setting the latter metal free; so tha while on the one hand an equivalent of simple cyanid is consumed, on the other hand an equivalent is forme and the equivalent previously engaged to form wit the silver the double salt, is also free; and thus fa there is an increase in the quantity of simple cyanid of potassium. But, if the positive metal is silver, th cyanogen combines with it and forms cyanide of silver for cyanogen is a gas, and like oxygen will combin with metals in this its nascent state; though, unlik oxygen, it is a compound body, consisting of 2 equ valents of carbon + 1 of nitrogen, whence it is al termed bi-carburet of nitrogen. Well: cyanide silver is insoluble in water, and hence would form a insulating crust on the silver plate were it not for th presence of cyanide of potassium in excess in solution it readily dissolves in this, and so keeps up th strength of the solution; and the extra element cyanide of potassium, mentioned above, is thus ne *tralized.*

Having thus described the general character of *cyanide* solution, it remains for us to give the cesses by which the several elements are most favourably brought together.

95. *Cyanide of Potassium.*—To obtain this, we set out with the ferro-cyanuret of potassium, or yellow prussiate of potash of commerce; and as this prussiate is readily accessible at all chemists', it is better in general to purchase than to make it; the mode by which it is obtained will be found in any treatise on chemistry. It consists of 1 equivalent of cyanide of iron + 2 equivalents of cyanide of potassium. It is of a bright yellow colour, and is converted into the colourless simple cyanuret in the following manner:—Take 4 oz. of the yellow prussiate, break it in small pieces, and dry it well on a plate of iron; then reduce it in a mortar to exceedingly fine powder. Dry and pound in like manner 1½ oz. of carbonate of potash. Incorporate the two ingredients thoroughly. Place a Hessian crucible in the fire; and when it attains a red heat, throw into it the prepared mixture, and closely cover the crucible. Keep up the heat, and the contents of the crucible will soon fuse, and the fluid mass will become red-hot. After this, immerse in it, from time to time, a hot glass rod; the mass, which adheres in the early stages of the process, is brown on cooling; as the heat is continued, it appears yellowish, and finally, colourless and transparent. The operation is then complete: the crucible must be removed; and after its contents have been allowed to settle, the fused mass may be poured off: the greater portion of which consists of the *simple cyanuret of potassium.*[*] The impurities contained in this product are not detrimental to its use, in a general way, for the purposes in view; however, in cases where it is required pure, it must be boiled in strong alcohol; and when the alcohol cools, the pure cyanide will be deposited in the form of small white crystals. This salt is very deliquescent,

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[*] This method was first described by Messrs. Rodgers, in the *Philosophical Magazine* for Feb. 1834; and since by Prof. Liebig

and must therefore be retained in close bottles; it will readily be recognised by its powerful odour,—similar to that produced by peach blossoms. The mere mention of *prussic acid* almost entering into its composition, will be sufficient to induce my readers to exercise common caution in handling it. A solvent solution is prepared by adding two ounces of this salt to a pint of rain, or of distilled water; when the salt is well dissolved, the liquid is ready for use.

96. *Silver Solution.*—Silver may be presented to the above solution in various forms; as the oxide, the chloride, the carbonate, the nitrate, &c.: solution will in either case occur; and the double cyanide of silver and potassium will be produced. But since the silver, as we hinted before, must become a cyanide of silver, before it can thus unite with the cyanide of potassium, it is obvious that one portion of the solution must give up its cyanogen to the silver, and take to itself the bodies previously in combination with that metal. So that, from the oxide of silver, potash would occur in the solution; from chloride, chloride of potassa; from carbonate, carbonate of potassa; and from nitrate, saltpetre. Of these, the least likely to interfere with this general action is the potash; and hence, oxide of silver has been frequently used. It is thus prepared:—

97. *Oxide of Silver.*—Place pieces of silver in a glass vessel, and pour on them about equal parts of water and strong nitric acid; the metal will soon dissolve, giving off fumes of nitric oxide. Should the solution have a green hue, which is invariably the case, unless the metal has been obtained fine from the refiners, it indicates the presence of copper; in which case immerse some pieces of copper in the solution, and the nitric acid, by elective affinity, will combine with the copper; and a precipitate of pure silver, in the form of a greyish powder, will take place. Throw away the liquid, and wash the silver precipitate several

times in sulphuric acid and water, and afterwards in water alone. Then re-dissolve it, as before, in nitric acid and water; and a *solution of pure nitrate of silver* will be obtained. Place this in an evaporating dish, or a saucer, and apply the heat of a spirit-lamp, or place the saucer by the fire-side, till some portion of the liquid is driven off in vapour. Allow the residue to cool, and it will shoot out into long colourless transparent crystals, which are *nitrate of silver*. They must be handled with care, as they possess the property of staining animal and vegetable substances with an almost indelible black; fused nitrate of silver being the lunar caustic of surgery, and the main ingredient of marking ink.—Next prepare some *lime-water*, by stirring lime into water, and filtering the solution. As lime is very sparingly soluble in water, requiring, at 60° Fahrenheit, 750 times its weight, it is necessary to make an abundant supply. Place the lime-water in a glass or other vessel, and drop in it a *few* crystals of nitrate of silver: the colourless solution will instantly assume an unsightly brown hue; and, after remaining quiescent for a time, the *oxide of silver* will subside in the form of a dark brown precipitate. The liquid is then poured off, and the precipitate is washed with water. Before throwing away the liquid, fresh lime-water should be added to it; and if the dark hue recurs, the precipitate must be allowed to subside again: if no change takes place, it may be inferred that the silver is all extracted. The oxide of silver should not be dried; but be kept in bottles with water. A quarter of an ounce of oxide of silver, added to a pint of the solvent solution, forms a very useful plating solution.

98. *Cyanide of Silver.*—But as the above solution is impure, in that it contains as much potash as is equivalent to the oxide of silver added, it may not be *applicable to* accurate experiments; and as the potash *is produced, in* the formation of cyanide of silver, at

the expense of a certain portion of the cyanide potassium, it is a wise plan, for it is no more cos to form the cyanide of silver in a separate vessel, to wash away the impurities before adding it to solvent. Take then a neutral solution of nitrate silver; add carefully a solution of cyanide of pota sium, when a white precipitate of cyanide of silv will fall; continue adding until precipitation ceas The liquid, which is a solution of nitrate of potash saltpetre, is to be poured off, and the precipitate well washed. It will be pure cyanide of silver, if the materials employed were pure; and it is now fit to be added to the solvent liquid, to form a plating solution free from impurities.

99. *Preparation of the Gold Solution.*—Warm a pint of pure rain or distilled water, and dissolve in it two ounces of cyanide of potassium as before; then add a quarter of an ounce of oxide of gold. The solution will at first be yellowish, but will soon subside to colourless transparency. Those not versed in chemical manipulation will be wiser to purchase than to prepare oxide of gold; but, for general information, I give the process:—Dissolve pure gold in two measures of muriatic with one of nitric acid; evaporate to dryness; dissolve the residuum in twelve times its weight of water; add to this a solution of pure carbonate of potash, dissolved in twice its weight of water; apply a moderate heat, about 170°, and a reddish yellow precipitate occurs. This is the *hydrated* per-oxide of gold. Wash it well; and, to render it anhydrous, boil it in water. It then assumes a brownish-black colour, which is the oxide required.

100. I by no means give these as *standard* proportions of the several ingredients required. They are the proportions which I employed with success in gilding and plating the series of metals (submitted to the Electrical Society at their meeting, Sept. 21, 1841), by the battery process to be hereafter described.

When the same object is effected by the employment of a single cell, it will be requisite to alter the degree of saturation according to circumstances; to which, however, I shall have further to allude in the sequel.

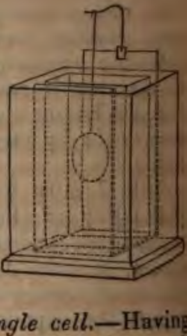
101. *Single cell for plating and gilding.*—The necessity of economising solutions of such value as these, has led to certain modifications in the apparatus, contributing to that end. The porous cell, (§ 17.) which in other arrangements contains the *zinc* and acid, and is surrounded by the copper or other negative element, in the present process contains the *cyanide solution*, and the negative element or object to receive the deposite, and is surrounded by the zinc, &c.

102. This arrangement will be readily understood by a glance at the annexed woodcut, which represents a porcelain cell containing a cylinder of zinc; and an inner porous tube filled with the solution of silver or gold. Connection is made between the zinc and medal or mould by a binding screw; or by mere contact, as in the figure.

103. I must again dwell upon the philosophy of the action of this arrangement, and return to first principles, in order to impress them more firmly on the minds of those who read these pages with the intent to repeat the experiments. For it is a matter of some importance, in employing the costly salts of the noble metals, to have the principles of the experiment traced out as distinctly as possible.

104. In the arrangement just described, the nature of the deposite will depend upon the principles elsewhere (§ 78.) set forth; and *à fortiori*, from the facility with which the salts of silver or gold are

decomposed, there will be a much *greater* chance of releasing hydrogen, and spoiling the experiment; to prevent which, therefore, ample provision must be made. For instance, if the silver solution is *weak* in proportion to the *energy* of action between the zinc and acid water, the electricity developed will be *more* than sufficient to release pure metal, and hydrogen will be evolved, the result being a deposition of oxide. Or, if the balance between the strength of the solutions be duly adjusted, the relation between the size of the zinc and of the medal or mould may be such as to determine the same result. It is therefore requisite that the water which excites the zinc, should contain *very little acid*,—a few drops, more or less in proportion as the cyanide solution contains more or less of the oxide; and that the strength of the latter should be maintained by a fresh supply of oxide from time to time.



105. Another and, in some cases, more convenient form for the single-cell apparatus is given in the annexed woodcut; in principle it differs nothing from the former; the porous cell to contain the cyanide solution being flat, affords the means of immersing a large medal, without an extravagant supply of liquid. The zinc which envelopes the porous cell is also flat. The connections are made as before.

106. *Plating by means of a single cell.*—Having charged either of these arrangements with the weak acid water and the solution of silver, let it remain for a few minutes; in order that the porous cell may be moistened through, and that action may commence as soon as the circuit is completed. Then attach a *thin*,*

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* *This* principle, so often alluded to, of retarding or restraining

pliable wire to medal or mould, and place its other end in contact with the wire attached to the zinc: complete the circuit by immersing the metal in the silver solution, and a deposition will *instantly* take place. It will present a *dead* whitish appearance.

107. Should the silver deposite present a whitish surface, streaked with perpendicular *black* lines, it may be regarded as an indication that the action is attended with a development of hydrogen: this must be prevented by some of the means so often mentioned. (§ 78, &c.) By careful attention at the commencement of the process the right degree of action is readily obtained; and if the process is continued (with occasional watching) for about half an hour, the medal will be beautifully coated with *dead* silver. In that condition it may remain, after being washed, and dried in blotting paper. Or, if a burnish is desired, the leather and plate-brush must be used.

Mr. Bain has patented an instrument, which he styles a "Voltaic Governor." The plates of the voltaic arrangement are immersed to a depth sufficient to produce the electricity required. They are suspended in the liquid as weights to a clock-work arrangement. When the action diminishes, a keeper from an electro-magnet, through which the current passes, is moved, and the plates sink until enough of electricity is generated to cause the electro-magnet again to attract the keeper.[*]—If, instead of plating medals, the object is to deposite silver in a mould, as mentioned elsewhere, the same preparations are to be made; but the mould should be allowed to remain for some minutes (more or less according to the thickness required) subject to the action of the current. It may then be removed, and after being washed with water, and afterwards with

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the energy of the action, is regarded in the employment of thin wire; *it is* a very valuable adjunct to the other means (§ 78) of *obtaining* the same end; and may often be adopted with advantage.

[*] *Vide* Mech. Mag., 5th Aug. 1843.

water containing a few drops of nitric acid, ma
placed with proper connections in a copper solu
(§ 57.) to remain there till it is sufficiently backe
with this metal.

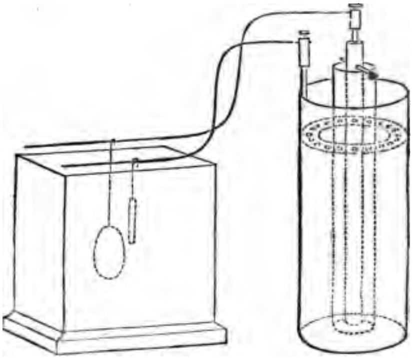
108. *Gilding by means of a single cell.*—
operation of gilding is conducted much in the sa
manner as that of plating,—gilding, however,
quiring a little longer time, and occasionally
solutions.

109. The operations of gilding and plating seem a first to have been very generally effected by means of the single cell, in a manner more or less in accordance with the directions I have just given, as the nature of the case permitted. In fact, *plating* by this process had been adopted on a scale of some magnitude in the great manufacturing town of England; the strength of the solution being maintained by fresh supplies of the oxide of either gold or silver. And if attention be paid to the instructions given, there is little fear of failing.

110. Before describing a method which appears far superior to this, I would direct attention to the source whence the silver and gold, in the single cell process, are obtained, viz. from the *oxides*, for instance. For every ounce of these metals deposited, a quantity of the oxide must be furnished, which shall contain in it an ounce of *pure* metal; and hence for every ounce of *metal*, much *more* than an ounce of *oxide* is consumed. The time and trouble required to effect the combination between these metals and oxygen is by no means inconsiderable; and hence the expense of first producing the oxide of gold or silver and then releasing either from the after-combination with cyanogen, far exceeds the actual cost of the metal employed: *how* far depends upon circumstances. The object, however, may be accomplished with far more certainty, and at considerably less expense by means of an additional cell, *(§ 56.) and* a plate or wire, &c. of gold or silver, to

up the strength of the solution, as in the of sulphate of copper. This method is now ed generally by the several patentees ; for experi- s with solutions of silver and gold in union with gen, have shown that *cyanogen nascent at the ve plate in a decomposition cell will combine silver and also with gold.* This furnishes a s of gilding and plating, by the use of a generating to furnish the electricity, and a decomposition to contain the cyanide solution ; the nature of hanges produced has already (§ 94,) been de- d.

l. *Battery process for plating and gilding.*— enerating cell for acting upon solutions of silver not be large. A pint Daniell, or a series of imilar to that in the woodcut, is sufficient for



r medals than can be placed in the decomposition ttached. The latter is of porcelain or glass. Of e, the size varies according to the extent of xperiment. The zinc may be used unamalgam- and excited with salt and water ; the copper as usual, contains a solution of the sulphate.

(§ 57.) Gilding may be better accomplished by using three cells of Daniell's battery.

112. *Voltaic Condenser.*—Prof. De la Rive has introduced an instrument, which he has named the *Voltaic Condenser*,* and which promises to be of some service in electro gilding and plating. Its property is to give to one cell of a battery the intensity of two or three, being the power required for these processes; and it does this at the expense of only *one* equivalent of zinc. It is well known to electricians that at the moment contact is made with a battery, so as to send a voltaic current along a wire in one direction, a *secondary current*, which endures but for an instant, is induced in the wire in the reverse direction; and when contact is broken, so that the original current ceases, the secondary current is induced to move in the direction contrary to its original motion; and therefore in the *same* direction as that pursued by the primary current, when contact was first made. The intensity of this current greatly depends on the quantity, the character, and the form of the wire employed; and if the wire is coated with silk and wound round a bobbin, the intensity is greatly increased;—M. De la Rive uses 100 convolutions of three stout copper wires, and places within the coil a bar of soft iron, the use of which will soon become evident. The object of the arrangement is to convey the battery current, and with it the secondary current through the solution to be decomposed.

113. For example, we will select the gold solution to illustrate the use of the *comdenser.* Metallic connections are applied between the ends of the coil and the two terminations of a Daniell's or Smee's battery. The connections are continued to a vessel containing *the gold* solution, the arrangement being somewhat like *the figure* ∞, where the generating cell is to the right, *the coil* in the centre, and the decomposition cell to

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* *Vide Arch de l' Elect.* No. 8. p. 173, and Elec. Mag. p. 38.

the left. The current, on leaving the battery, has thus the choice of two paths, the one being through the coil, the other through the solution; but from the great comparative resistance of liquids, compared with metals, far the larger portion would pass through the coil, while a comparatively small share would traverse the solution of gold. In passing through the coil, however, it converts the soft iron core into a magnet; this magnet instantly attracts a piece of iron, which is so arranged that, on being raised, it removes a wire and thus breaks off communication between the coil and the generating cell, except by means of the cell containing the solution. The current therefore now passes through the gold solution. But when the coil ceased to be alone in the circuit, a secondary current was induced in the same direction as the original battery current; this, therefore, joins with the said generating current, and *both pass together* through the gold solution; by which means the actual power of the battery is very greatly exalted. Now, the iron core loses most of its magnetism, as soon as the liquid is included in the circuit; and hence the piece of iron, the raising of which broke contact, falls again, and the coil is again included, when the same phenomena recur; and thus, by a continued succession of breaking and making contact, the *current of a moment*, namely, the *secondary current*, is created, and employed with very great advantages. My readers must be content with this general description; and I must trust to their own ingenuity for making arrangements agreeable to these directions.

114. *Application of Heat.*—Considerable advantage accrues in all cases of the deposition of metals where adhesion is desired, by the use of heat. It expands the baser metal, and so far opens its pores, that the subsequent contraction, consequent on the effect of common temperatures, is likely to operate favourably in binding the metals together. It has other advatanges, espe-

[illegible] either of the
[illegible] in the [illegible]
ed.

123. Time appears to be the [illegible] requisite for p
[illegible] to the [illegible]
[illegible] The thickness of the deposit
course, depends on the duration of the action.
[illegible], and when [illegible] are not exposed to w
few [illegible] immersion may be enough; for sp
forks, [illegible] &c., subjected to much wear,
night, or even more hours; always taking c
watch the process at times, in order to prevent th
formation of the black lines; whenever they ap
the action must be renewed. Large object
those which are subject to a long action, shou
occasionally withdrawn, and their position
be altered; so that a uniformity of deposit may
Motion of the articles during the process has
recommended, and with some show of reason.
readiest method of producing it is to suspend the
in the solution from a common bottle-jack, and c

116. *Preparing surfaces to unite with gold and silver.*—But we are going on too fast; I must return to certain things preliminary to plating and gilding, which I had passed over, in order not to interrupt the progressive illustrations of the nature and preparation of the solutions. I allude to the preparation of the surfaces, previous to applying the metals; which is a point of such paramount importance that, unless duly regarded, all subsequent operations will be futile; and it would be in vain to hope for perfect adhesion between the metallic base and the deposit; the latter will rise up in blisters where the surface is not properly prepared, and can easily be rubbed off.

117.—There are two methods of preparing metals for the reception of other metals,—the wet way, and the dry way. The experiments of M. Becquérel and others, are decidedly in favour of the latter; but as it cannot be adopted, except in certain cases, where the work of the article is plain and the article itself is not delicate, it will be necessary to describe both modes. The main intent of cleansing is that the contact between the two metals may be perfect; and it effects this by removing grease and all extraneous matter, especially the oxides, which are ever found on the surface of the less noble metals.

118. *Cleansing by the dry method.*—The advantage of the dry process over any in which moisture has been employed, is that, in the latter case, several seconds, at least, must always pass between the act of removing the article from its last liquid bath, and placing it in the solution of the metal to be deposited; and during this short interval, the article, or some portion of it, very frequently undergoes an alteration, trivial indeed, but still an alteration, by the action of the air, which produces a film of oxide, infinitely thin, it is true, yet quite enough to militate against the success of the experiment, as regards permanent adhesion. Therefore, wherever the dry process can be adopted, it is deci-

dedly the better; although, from the very nature o articles subjected to the process, the number of c in which it is available is very limited. The dry cess is merely the operation of scouring with sand glass, or emery paper, as the case may be, or with v fine powder of pumice stone; using clean brushes, u terly free from grease. Sometimes fine files may used; indeed all depends on the value and charact of the article operated upon. It must be remember throughout that grease and oxide are the great enemies to be expelled; and therefore, especial care must b taken to avoid contact with the moisture of the hand, which is of a nature to produce either.

119. *Cleansing by the wet method.*—The solutions employed may be divided generally into two classes, the acid, and the alkaline; the action of the former is directed more towards the removal of oxides, &c.; that of the latter to the removal of grease. As a rule, I would always follow the use of an acid bath by an alkaline, having first washed away the acid in several waters; and this may be done, whether the operation commence with an alkaline bath or not. The following are some of the modes in use; they are all effectual according to the circumstances which give preference to one over the other:—The method recommended by M. Boettiger in his account of gilding, given in the *Annalen der Chimie und der Pharmacie*,* may be adopted He says, "it is very necessary to rub the metal according to circumstances,† with extremely fine sand, moistened with hydrochloric acid mixed with a little chalk so that there shall remain no trace of oxide of copper." Another effectual method is immersing the article i a mixture technically termed "pickle." This may b made of

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* Vol. xxxv. p. 350.

† *i. e.* when it can be done without injury to the object of experiment; and this, too, must be the guide in the application o *the other modes.*

Sulphuric acid	64 parts.
Water	64 ,,
Nitric acid	32 ,,
Muriatic	1 ,,

The "pickle" is used by tying a wire ronnd the article and immersing it for a second or two; the action is very energetic, and, of course, is not suited to the preparation of medals:—for medals, the mixture should be very much diluted, and they should remain in it for a time. A mere bath of dilute nitric acid is often used. Nitric acid, mixed with sea-salt and soot, is often rubbed on the article. Concentrated sulphuric acid and sea-salt is another mode.—Of the alkaline solutions are caustic soda, or solution of soda and ammonia, or caustic soda and sal ammoniac; or the articles may be boiled in a solution of common soda or potash, which is a very good method of cleansing them.

120. Whatever solution is used, whether acid or alkaline, or the detergent paste of soot, or chalk and acid, fresh water must not be spared for rinsing off all remaining traces; and the article must be dried for immediate use by pouring over it *boiling* distilled, or rain water; or, if the process of deposition is not to be commenced immediately after the rinsing, it may be buried in hot or cold box-wood sawdust, until required; it may often be dried for immediate use in hot sawdust. In addition to the detergent methods already given, an ancillary means, which has been found effectual, depends upon the fact, that metallic and other surfaces, after exposure to the air for some hours, become coated with a film of air so intimately as to retain it, even (as in electrotype cases) between themselves and any metal deposited upon them. In fact, we have been advised, in copying large subjects by electrotype, to take advantage of this, and to allow the film to arrange itself, before the plate is submitted to the action of the battery. For it is *found* that the presence of this natural film *very materially* operates in preventing adhesion between *the plates* and the deposite: whereas, in the absence

the film, unless its place has been supplied by something else, other things being in order, the *two* will effectually become *one*. We are advised, too, after soldering a wire to a copper plate, to allow the latter to remain an entire day, to regain the film of air which had been driven off by the heat. Carrying out this principle, the boiling alkaline solution and the boiling water answer a double end; and hence are very effectual means of promoting perfect union between the metals. Heat operates still more favourably in causing the expansion of the metal, as I mentioned when recommending its adoption in the process itself of electric deposition. Iron may be prepared and cleaned by electrolytic action, as described elsewhere. (§ 166.)

121. *Amalgamation to promote adhesion.*—Another method in this preparatory stage of the proceedings, to which I shall allude, is that recently recommended by M. Becquérel;* and which promises to be of great avail in ensuring a successful termination to the experiment. After the articles are thoroughly cleaned, according to the instructions now laid down, they are dipped into a solution of proto-nitrate of mercury; when taken out they are washed in abundance of water; and are then rubbed with leather, in order to promote the equal spread of the mercury. These operations are repeated until the whole surface is well coated with mercury. The ultimate character of the metallic deposite depends on the surface given to the mercury; if the employment of the leather is only such as is needed to effect the more equal diffusion of the mercury, the surface is dull or dead, and so is the deposite; whereas, if brisk friction is applied, and the mercury receives a good polish, such will be the character of the metal thrown down. And thus may *burnished* gold or dead gold be produced at pleasure. By *adopting this* method of giving a mercurial coat as the

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* *Vide* Les Comptes Rendus, July 3, 1843.

foundation for the plating or gilding (and it is especially valuable for the latter), a double advantage accrues; the close adherence between the metals is ensured,—and a coating of gold of any thickness may be thrown down. The mercury is subsequently driven off by heat, either heat applied for the purpose, or the heat employed in some of the operations by which the work is finished. The last cleansing method I have seen, and it is a capital one, is to scour the surface with Calais sand, moistened by the silver or gold solution, and rubbed in with a scratch brush.

122. German silver is prepared by allowing it to remain for three or four hours in a cold solution of carbonate of potash. It is then washed in cold water, and dipped into dilute nitric acid. After again washing and drying it, it is rubbed with leather; and immediately before placing it in the silver solution, it is dipped into a solution of common salt, containing a little gum.

123. *Cleaning Electro-plate.*—Electro-plating, especially of dead silver, is very liable to turn yellow, after a few days' exposure to the light. M. Mourey found* that this was due to the decomposition of a cyanuret or a sub-cyanuret remaining on the silver surface on its emersion from the solution. He removes it in the following manner:—The articles are covered with a thick layer of dissolved borax, and, being placed in a muffle, are submitted to a heat somewhat below cherry-red, which is sufficient to calcine the borax. They are then thrown into water acidulated with sulphuric acid, and allowed to remain. After being withdrawn from this, they are washed in water and dried first in hot saw-dust, and then on a stove or otherwise. The result is the production of that white colour so essentially requisite to dead silver, especially in articles of jewellry. I may add to this a process for *cleaning* tarnished silver in general, which, though not

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* *Vide* "Comptes Rendus," April 3, 1843. p. 660.

much known here, is practised constantly by the natives in India. A few tamarinds are placed in water contained in an earthen vessel, and the silver articles are boiled in it for a time, and they emerge clean and very white.

124. *Gilding-wax.*—The proper colour is given to the surface of electro-gilding by covering it with *gilding-wax*, and heating it till the mass begins to smoke. Gilding wax consists of the powders of saltpetre, sal-ammoniac, sulphate of iron and verdigris mixed with melted wax. This operation removes the brassy appearance, which the surface often presents, and gives the rich gold colour, on which the beauty of the work depends.

125. *Various metallic solutions.* — M. Louyet has used with great success a solution of bi-sulphuret of gold in cyanuret of potassium. This solution is neutral to silver, copper and brass, so that no action occurs on the surface of these metals until the circuit is completed. The bi-sulphuret of gold is prepared by passing sulphuretted hydrogen through a solution of bi-chloride of gold; or by pouring into such solution hydro-sulphate of ammonia. The bi-sulphuret is collected in a filter, where it must be well washed with *warm* not *boiling* water: it is then dissolved by pouring the cyanuret solution (§ 95.) through the filter. The solution has a clear gold colour; it is diluted for use to a pale straw colour.

126. M. Becqúerel has introduced a very philosophical mode of gilding by the single cell process. A solution was made of 1 gramme of dry chloride of gold, 10 of ferro-cyanuret of potassium* and 100 of water; it was filtered, and to it were added 100 grammes of a saturated solution of yellow ferro-cyanuret of potassium:—The solution was used in that state, or diluted with once or twice its bulk of water according to the character of surface desired. This solution is placed in the porous tube of a single cell,

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* The prussiate of potash of commerce.

(§ 18.) and into the cell surrounding the zinc is poured a solution of a similar character with the exception that it *does not contain any gold;* but, in lieu thereof, it contains a little common salt. Unmalgamated zinc is used.

127. There is not space to give detailed accounts of the many other solutions that have been used; let it suffice to mention in brief a few:—

M. de Ruolz has employed,

1. Cyanuret of gold, dissolved in simple cyanuret of potassium;
2. Cyanuret of gold, dissolved in the yellow ferrocyanuret;
3. Cyanuret of gold, dissolved in the red ferro-cyanuret of potassium.
4. Chloride of gold dissolved in the same cyanurets;
5. Double chloride of gold and potassium dissolved n the cyanuret of potassium;
6. Double chloride of gold and sodium dissolved in soda;*
7. *Sulphuret of gold dissolved in neutral sulphuret of potassium.*

The latter is singularly valuable.

He uses cyanuret of silver in yellow ferro-cyanuret of potash. Where 6 cells in series are required for gilding, 4 are sufficient for plating.

128. He effects *platinating* with the double chloride of platinum and potassium in caustic potash, with the same ease and facility as plating and gilding; but when he used cyanuret solutions of platinum, like those of gold or silver, it required one or two hundred times the duration of the experiment to produce a corresponding result.

Lead is precipitated from oxide of lead dissolved in potash.

Tin is deposited on iron and zinc, &c., from a *solution of oxide* of tin in potash, or tin in cream of tartar;

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* The analogous salt of potash does not succeed.

which latter is the solution employed for tinning pins, the process being in truth an electrical one; for the pins and the tin are thrown into the liquid, where the latter receive a coating.

Zinc is deposited, especially on iron; the solution is not named.[*] Elkington's solution for zincing is given in the sequel. (§ 138.)

129. M. Boettiger uses for *gilding* one part of chloride of gold, as neutral as possible, and 100 parts water, in which he allows the action to be repeated about half-a-dozen times, of a minute's duration each, and washes the article between each operation with fine linen in pure water. For *platinating* he has a corresponding solution of platinum. He has also employed one part of chloride of platinum, 100 parts water, and 8 parts hydrochlorate of soda; or one part ammoniacal chloride of platinum, dissolved, with 8 parts of sal-ammoniac, in 32 or 40 parts of water. The latter solutions are used without the voltaic current to give a thin coating; which may doubtless be increased by the voltaic action.

130. Mr. Woolrich uses the following solutions:—

He first prepares what he terms the solvent, or sulphite of potash, thus:—28 lbs. of the best pearl-ash, and 30 lbs. of water are boiled in an iron vessel: the solution is allowed to cool, and is then filtered. To this are added 14 lbs. of distilled water; sulphurous acid gas[†] is then passed into the liquor until it becomes saturated; and the liquor is filtered for use.

Silvering-liquor.—12 oz. of crystallized nitrate of silver are dissolved in 3 lbs. of distilled water. The solvent just described is gradually added, so long as a whitish precipitate falls. The supernatant liquor is

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[*] *Vide* Les Archives, June 7, 1842.

[†] This gas may be obtained by applying heat to a flask containing sulphuric acid and pieces of well-burned charcoal. The gas should be passed through water to free it from any acid it may have carried over.

poured off, and the precipitate washed with distilled water. To the washed precipitate is added as much of the solvent as will dissolve it; and then ⅙th part more, so that the solvent may be in excess. After being well stirred, and allowed to remain for 24 hours, the liquor is ready for use.

Gilding-liquor.—Four oz. troy of fine gold are dissolved in a mixture of 11 fluid oz. nitric acid, 13 muriatic acid, and 12 distilled water: the solution is evaporated and crystallized; and the crystals are dissolved in 1 lb. of distilled water; the gold is then precipitated by pure magnesia, the precipitate is first washed with distilled water acidulated with nitric acid, and then with water alone. To the washed precipitate is added enough solvent to dissolve it, and ⅕th more. After being stirred and remaining 24 hours, it is fit for use.

Coppering-liquor.—7 lbs. of sulphate of copper are dissolved in 30 lbs. of distilled water, and to this is added solution of carbonate of potassa until precipitation ceases. The precipitate is washed, and dissolved in the solvent as before, one-third more being added. This must stand for twenty-four hours as the others.

131. Mr. Tuck has prepared the following liquid. He dissolves 70 parts by weight of bi-carbonate of ammonia in distilled water, to which he adds by weight 56 parts of sulphate of silver, or 134 parts of cyanide of silver, and boils the liquor until the silver salt is entirely dissolved. The strongest solution that he has employed was in the proportion of half an ounce of sulphate of silver and 107 grs. of bi-carbonate of ammonia to a pint of distilled water.

132. Mr. Briant, of St. Petersburgh, gives the following preparation of *gold solution*, as superior to any other. He makes a solution of 6½ solotnik (428 grs.) of gold in *aqua regia* (nitro-muriatic acid), by aid of a sand-bath: he boils it down to one-fourth, when crystallization occurs; he evaporates, but not to dryness.

The crystals are then dissolved in hot water, and half a pound* of powdered magnesia dissolved in water is added. It is filtered warm: if the liquor is dark, the magnesia is not all dissolved, when it must be boiled again. It is now washed in the filter, and the *hydrated* oxide of gold remaining in the filter is placed in a flask, and on it is gradually poured half a Russian pound of nitric acid; after the effervescence ceases, it is again filtered and well washed; and the chocolate-coloured residuum is boiled in a hot prepared solution of 1 lb. 22 solotnik (7766 grs.) of prussiate of potash; when it boils, 10 solotnik (6·58 grs.) of caustic potash, previously dissolved in cold water, are added, and well mixed. When cool, the solution is filtered for use: the sediment now remaining in the filter is oxide of iron.

133. Major Von Jewreinoff gives the following *silver* solution:—4 parts of dry powdered prussiate of potash are well incorporated in a mortar with 1½ parts of pure potash, and are melted in a closed vessel till the product becomes transparent and dazzling white. Chloride of silver, prepared by throwing salt into a solution of nitrate of silver, is dissolved in this solution and filtered for use.

134. A writer in the *Mechanics' Magazine*, Mr. Rockline, has used the following solution:—Oxide of silver is dissolved in citric acid; the solution is evaporated to dryness, and the residual salt is exposed in a tube to 212° Fahr., when a current of dry hydrogen is passed over it for a few minutes. The salt is then dissolved for use in *cold* water. He says this solution must not be heated.

135. *Other applications of Electro-Gilding.*—On the continent, and here also, this art has been rendered available in gilding the springs and works of chronometers; and one experimentalist, M. Perrot, has "undertaken to gild at the same time all the movements of *a watch,—to* gild them, not only in their places, but

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* *A Russian* pound, of 96 solotniks, is equal to 6318·5 grs. Eng.

hile in motion."* M. Boettiger, to whom I have lready (§ 129.) alluded, has employed for gilding, the i-chloride of gold, and has prepared copper surfaces, y first depositing upon them platinum. M. Hamman, n engraver of Geneva, has deposited a coat of *gold* nstead of one of *varnish* on plates intended for ordi- ary etching, and has traced the design most accurately, hrough this exceedingly delicate layer.

136. Electro-gilding has been successfully applied n protecting and permanently fixing Daguerréotype ictures. It is well known that thin films of gold are ransparent. A thin film is therefore deposited upon he surface of the finished plate, and effectually secures he picture from destruction; while it does not in the east hide it from the eye, or detract from its beauty.

137. *Daguerréotype Plates.*—The art of electro-plating may be made available in preparing Daguerréotype plates. The lovers of this attractive art may now experiment upon plates of their own preparation. They may be prepared in two ways: either by plating a burnished and prepared copper plate; or by depositing silver, with due precautions, on a burnished plate, and afterwards backing up with copper. The latter is the most effectual, especially to those who are not skilled in the plans adopted by the artizan for the treatment of burnished surfaces.

138. *Electo-zincing.*—Messrs. Elkington have patented a process for applying zinc to iron, in order to protect it from the atmosphere. They say that the best and cheapest solution is the sulphate of zinc, of which they dissolve a pound in a gallon of water; and electrolyze it with a battery of feeble power.

139. *Reduction of alloys.*—This has been long deemed impracticable; but recent experiments have proved that it is possible. M. de Ruolz was the first to deposit a galvanic film of *bronze* on other metals,

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* *Vide* Arch. de l'Electricité, No. 1. p. 276.

by dissolving cyanide of copper and oxide of tin, in certain proportions, in cyanide of potassium, and allowing a constant battery to act upon the solution. Professor Majocchi reports the deposition of an alloy of *lead and iron*, which he says is much harder than lead, and melts at a much higher heat. Protosulphate of iron is added to a solution of lead in nitric acid, in such quantity that the resulting solution shall not be very concentrated. Professor Jacobi obtained films of *brass* by preparing solution of cyanide of potassium, and throwing in copper, from a positive plate of copper, and then zinc from a positive plate of zinc; after a certain time brass was given off.

140. *Electrolysis of fused compounds.*—Mr. Arthur Wall has a patent for purifying iron-ore from sulphur, phosphorus, and other such elements, by applying a powerful voltaic current to the metal while in a state of fusion, either when it is in the smelting furnace, or while it is in the moulds; and he prefers continuing the current until the metal is solidified. In reference to these experiments, Dr. Ure is understood to have stated that a current was passed through a rod of soft iron, at a moderate heat, and, in a few hours it was converted into steel.

141. Mr. Napier has patented a process for reducing copper from its ore by the aid of an electric current. Native sulphuret of copper, for instance, is roasted in the usual way, and is then melted with lime and soda as fluxes; the pot is now so connected with a battery as to be the negative pole, or place for receiving deposits; and a plate of iron connected with the positive pole is thrust beneath the surface of the fluid mass; a solid mass of copper is soon found deposited on the inner surface of the pot, the quantity of which is stated to be more than a dozen times that of the chemical equivalent of the electric action.

142. Mr. Parker has a patent for plating and gilding by means of fused iodides, chlorides, and phos-

phates of the metals. As an example, he takes 6 lbs. of chloride of silver, fused in a silver or an enamelled iron vessel; when fluid, he immerses in it the article to be plated, which is in connection with the negative end of the battery, and a plate of silver connected with the positive end: to increase the quantity of fluid, he sometimes adds to it from 3 to 10 lbs. of iodide of potassium, or even the iodide of mercury or copper, in the proportion of 1 or 2 lbs.

For a gold fluid he takes 20 oz. of iodide of gold and 80 oz. of iodide of potassium or sodium, which he subjects to similar treatment, using, of course, a gold instead of a silver plate.

143. Mr. Ritchie has a patent for extracting copper from its ore by a very simple voltaic arrangement. He dissolves the calcined copper ore in dilute sulphuric acid, and places the solution in a large rectangular vessel; on the upper surface of this, he pours a mixture of two parts water and one saturated solution of sulphate of iron, taking care that mixture does not take place with the lower liquid; he then places an iron plate as a generating metal in the iron solution, and a plate of lead in the copper solution to receive the deposit, connecting the lead and iron with a wire. It is stated that, by this process, galvano-plastic objects may be easily obtained on a large scale.

144. *Magneto-electro-plating.*—Mr. Woolrich employs the electricity obtained from a magneto-electric machine. When coils of wire are moved in front of magnets, currents of electricity are generated; by proper adjustments he has so arranged this apparatus that he can deposit three or four hundred ounces of silver per week; by moving the coils at a greater or a less velocity, he can modify the current; or more simply, by altering their distance from the magnet. These machines are expensive at the first outset; but, as there is little wear and tear, and no consumption of materials, and, as the power of the magnet is not reduced by use, they

are, in many cases, very desirable, especially where steam-power is at hand to impart motion. It is said that Elkington now adopts this, in place of the battery process.

II.—DEPOSITION OF THE OXIDES OF METALS ON METALS.

145. *Metallo-chromes.*—Hitherto we have been considering the deposition of *metal* on metal; it remains to give a familiar description of the mode of depositing *metal in union with oxygen, i. e.* a *metallic oxide* on metals. The most beautiful experiments of this kind are those described by Nobili,* and recently repeated and considerably modified by Mr. Gassiot.† The productions are known by the name of *metallo-chromes.* A saturated solution of acetate of lead is prepared, and poured into a shallow vessel, in which has been placed a highly-polished steel-plate. A wire from the *positive* end of a series of three or four Daniells, is made to touch the plate. Then, if another wire from the *negative* end of the series is held in the solution, over the plate, a small tinted circle makes its appearance on the polished surface beneath the wire, and rings of colour of the most brilliant hues rise from the centre and expand to the circumference. The colours commence with silver-blond, and progress onwards to fawn-colour, and thence through various shades of violet to the indigos and blues; then through pale blue to yellow and orange; thence through lake and bluish lake, to green and greenish orange, and rose orange; thence through greenish violet and green, to reddish yellow and rose lake, which is the highest colour on the chromatic scale.

146. Coloured figures of varied character are obtained by modifying the shape of the electrode connected with the negative end of the battery; using, *instead of* a point, a slip of metal, a disc, a ring, a con-

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* Scient. Memoirs, Vol. I. Art. 5.

† Proceed. Elec. Soc. Dec. 17, 1839, 4to.

vex or a concave circle, a cross, or other pattern. By the employment of a large disc, and small steel plates, and by very careful manipulation, a uniform tint may be given to each plate, and the chromatic scale of forty-four colours may be obtained. For this purpose each experiment must be timed by a pendulum, and one second being given to the first plate, the duration for the rest must increase by a second for each. It is absolutely essential in operations of such extreme delicacy that all the plates be of the same thickness, so that, when adjusted to their position, they may remain at the same distance from the disc. Many more than forty-four specimens will be produced, which must be placed in order, and the similar tints rejected. The spoiled plates are cleaned with fine emery paper.—The best metallo-chromes are obtained by cutting a star or other pattern in card, and placing the pattern on the plate, beneath a convex or a concave disc.

The colours arise from the very thin films of oxide of lead, which are deposited on the steel plates: and are due to an analysis of light, similar to what occurs in a soap-bubble,* or in the film of air between a lens and a plate of glass, closely pressed together. No practical use had been made of these films.

147. *Deposition of Oxide of Lead.*—M. Becquérel has described† a means of coating metals with oxide of lead and oxide of iron, for the purpose of protecting them from the action of the air. He uses a *potash solution of lead*, which is prepared by dissolving 200 grammes‡ of caustic potash in two litres§ of distilled

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* The best mode of making a soap-bubble is to place a piece of soap, about as large as a pea, in a six-ounce vial, one-third filled with water; the vial is to be then placed in a vessel of water, and the water to be boiled. When the vial gives off steam pretty freely, it is to be corked, and then removed and sealed immediately. A horizontal film of soap may at any time be made by shaking the vial.

† *Vide* "Comptes Rendus," 3rd July, 1843.

‡ *A gramme* = 15½ gr. troy.

§ A litre = 61 cub. in.

water, and adds to it 150 grammes of protoxide of lead, —the *litharge* of commerce.—It is boiled for half an hour, and, after being allowed to settle, is diluted for use with its volume of water. Some of the solution is poured into a porous tube, which is placed in a vessel containing water acidulated with one-twentieth its weight of nitric acid. The nitric acid contains a platinum plate, connected with the negative or zinc end of a single cell of Daniell's battery; and the article to be coated with oxide of lead, as for instance, a plate of iron is placed in the solution of lead, and connected with the copper of the battery. In a few minutes the plate is covered with a coating of peroxide of lead, which arises from the union of the oxygen with the protoxide of the solution. The adherence is very strong, and if the article has been well prepared (§ 116, &c.), will sustain the action of the burnisher. The colour of the deposite is black with a brownish tinge; if the action is allowed to continue, it assumes the tint of yellow ochre. The liberation of hydrogen on the platinum plate is a sign that things are going on well. The solution must not be used to exhaustion, but be replaced by fresh, after perhaps a dozen hours of action.

148. *Deposition of oxide of iron.*—An *ammoniacal solution of iron* is used for obtaining a deposite of the peroxide. A hot solution of protosulphate of iron is prepared, and placed in the receiver of an air-pump, to abstract from it all air: a solution of ammonia is likewise deprived of air, and a little more than is sufficient to dissolve the protoxide of iron is poured into the former solution. This solution is used in the same manner as that of lead, described in the preceding paragraph, namely in a diaphragm decomposition cell; but care must be taken to keep it covered from the air, which has so great a power, on account of the oxygen it contains, of converting the protoxide into a peroxide. A few minutes suffice for the operation. The deposite

of peroxide is of a brownish red colour, having somewhat the appearance of precipitated copper; if the action continues, the colour becomes darker, and finally it is deep violet. The oxide will endure the burnisher. If the action is carried on at an elevated temperature, the adhesion is greater, because the contraction of the expanded metal binds the film more closely. The use of the diaphragm in these operations is to prevent the solution from becoming exhausted; for if the experiment were carried on under ordinary circumstances, the deposition of *metal* at the one electrode, and *oxide of metal* at the other, would very soon deprive the solution of its contents.

III. ELECTRO-ETCHING.

149. The results hitherto treated on, have been (with the exception of the deposition of the oxides,) all obtained at the *negative* metal; but there is a class of results of no inconsiderable importance to be obtained at the other terminal.

The plates of copper, in the decomposition cell, in connection with the copper of the battery, have been described as combining gradually with the oxygen released there, and being eventually consumed; so likewise the plates of silver or gold, which occupy the same relative position, are in a similar manner consumed. But as the varnish, (§ 31.) placed on moulds, effectually shields the parts protected by it, from the effects of electrolytic action, so also may the copper plates be protected, and the *destructive* action localised at pleasure.

150. If, for instance, the plates of copper be covered on any part of their surface with a stratum of varnish, that part will be excluded from the line of action, while all else is being consumed. Advantage has been taken of this, by coating plates with proper composition and *then tracing* through it any design, of which an etching *is required*. The plate in this condition is submitted

to the action of the nascent oxygen, and the surface is readily and effectually etched. There is some superiority too possessed by this method, over the ordinary etching by the use of nitric acid; for the operation can be conducted with considerable regularity; it can be rendered a slow or a speedy process; and the result can be taken out, from time to time, to be examined, and can be re-submitted in a moment. In fact, of so much importance has this mode of etching been deemed, that it is already one amongst the many applications of this principle for which a patent has been obtained.

151. *Process of electro-etching.*—Take a burnished copper plate, and solder to it a stout wire: heat the plate, and rub its surface with etching ground,* wrapped in silk; be careful to obtain an even coating; then smoke the covered surface over the flame of a candle. Varnish the back of the plate, as well as the wire, with shell-lac. Trace the design through the etching ground with a fine point. This done, place it in a decomposition cell, and connect it with the copper of a Daniell's or other cell, placing opposite to it a plate of somewhat similar size; after the lapse of ten minutes remove it, and "stop out" the fine parts with Brunswick black; return it to the decomposition cell for a second ten minutes; and again stop out the half tints; again submit it to action for ten minutes, and the operation is complete. Remove the etching ground by means of heat, and a perfect engraving will be found on the plate. The *exact* duration of the several operations, as well well their number, must be regulated according to circumstances. Electro-etching is an interesting experiment for the lecture table. At the commencement of a lecture, I have submitted a plate to electric action, and before the hour has expired, have distributed proof *impressions.*

* *Etching* ground consists of asphalte, wax, black pitch, and *Burgundy pitch.*

152. An etching ground of gold may be applied by submitting a copper plate well varnished on the back, to the action of an electric current passing through a solution of the cyanide of gold. When a perfect coating is obtained, the plate is removed; and the design is etched through the *gold film*. The plate is then submitted to the action of the battery, as before; and as the oxygen, released there, combines with the *copper*, but not with the *gold*, the design is permanently etched.—The process of etching is very speedily effected; and must, therefore, be very carefully attended to, lest, by proceeding too far, the plate be spoiled.

153. *Electro-etching Daguerréotype plates.*—In the description last given, the *artist's* hand must first trace the design, before the electric force will engrave for him; but Mr. Grove has described a process,* by which the pencil of nature does *all* the work. He has taken Daguerréotype plates,—those beautiful productions "drawn by light," and, having submitted them to the still further operation of Nature's laws, has succeeded in "engraving by electricity."

154. Though this process has not been perfected, so far as to produce plates fitted in *all* respects for the printer, yet, as it is one most important application of the subject on which we treat; and, as it furnishes, though not for the *printer*, yet for the *electrotypist*, plates from which *he* can obtain *perfect* impressions, and these to any extent, it claims especial notice in this treatise.

155. *Nature of Daguerréotype Pictures.*—The dark portions of these pictures are considered to be *silver*, and the light portions *mercury*; and hence, if they are placed in a solution, whose liberated element shall act on *one* of these metals, and not on the *other*; or if they are submitted to a solution, the liberated element of which combines *more* with one than the other, the result will be an etching.

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* *Vide* Proceed. Elec. Soc., vol. i. p. 94. Aug. 17, 1841.

156. Hydrochloric acid, diluted with half its bulk of water, has been employed. From hydrochloric acid hydrogen is released at the negative plate; and the great object is to dispose of it regularly, and as speedily as may be; for, if any hydrogen adheres to the surface of this plate, the surface of the plate to be etched, where it is *opposed* to this, will furnish an irregular result. The best plates for parting with the nascent hydrogen, are platinized silver, or platinized platinum. The distance between the two plates, (which are, of course, placed parallel,) should be about the fifth of an inch, which is *near enough* to ensure uniformity of action, and *not so near* as to allow the escaping hydrogen to interfere with the result.

157. In a process so delicate as that of etching out the microscopic delineations on these plates, due regard must be paid to the relation between the size of the generating pairs and the size of the plates themselves. The best mode is to have the generating pair and the decomposing pair of *one size*, or nearly so; and, as the solution employed will give up its elements with a feeble current, one generating cell is enough. Prof. Grove used a single pair of the *nitric acid battery;* but any other will produce the desired result. The *time* of action depends on the nature of the generating cell employed. With the nitric acid battery, (the energy of the action of which is great,) the effect was produced in from 25 to 30 seconds. With other arrangements it will be longer; and, possibly, as it is accomplished more slowly, the result will be more definite; and the experiment will be less liable to fail.

158. Having determined these several points, and shown the reasons on which they are based, (and I always wish to furnish *reasons* for all that is done; for when a man acts by mere directions, and arrives at ends he knows not *why*, I am well assured that his interest in the subject will soon be dissipated, and his path, instead of being pleasing and bright, will be

dull and gloomy;) the next arrangement is to prepare a wooden frame with grooves into which the two plates, viz., the Daguerréotype * and the platinized plate can slide, so as to remain firmly fixed in the required position. This frame is then immersed in the solution, and contact is made with the generating cell by touching, with the ends of the connecting wires, the edges † of the plates; and retaining them in contact for the given time. "The plate is then removed, and well rinsed in distilled water, and if the silver be homogeneous," ‡ will "present a beautiful sienna-coloured drawing of the original design, produced by a film of the oxychloride § formed; it is now placed in an open dish, containing a very weak solution of ammonia, and the surface gently rubbed with very soft cotton, until all the deposite is dissolved; as soon as this is effected, it should be instantly removed, and plunged into distilled water, and carefully dried. The process is now complete, and a perfect etching of the original design will be observed; this, when printed from, gives a *positive* picture, or one which has its lights and shadows as in nature; and which is in this respect, more correct that the original Daguerréotype, as the sides are not inverted: printing can therefore be *directly* read; and in portraits thus taken, the right and left sides of the

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* This plate must be well varnished on its back and edges.

† A small portion of varnish is removed from the Daguerréotype for this purpose.

‡ "It is very necessary that the silver of plates subjected to this process be homogeneous. Striæ, imperceptible in the original Daguerréotype, are instantly brought out by the nascent union; probably silver, formed by voltaic precipitation, would be found the most advantageous."—PROF. GROVE. This extract, illustrated as it was by the condition of the prints from some of the etched plates, indicates that the application of electro-plating, before described, (§ 137) *will eventually* be found of some service.

§ *Oxygen from* the water, and chlorine from the acid, are *released at the* Daguerréotype plate.

face are in their proper position."—"There is, however, *ex necessitate rei*, this difficulty with respect to *engravings* from Daguerréotypes; if the plates be etched to a depth sufficient to produce a good impression, some of the finer lines of the original must inevitably run into each other; and thus the chief beauty of these exquisite images be destroyed. If, on the other hand, the process be only continued long enough to leave an exact etching of the original design, which *can* be done to the minutest perfection, the very cleaning of the plate by the printer destroys its beauty; and the molecules of the printer's ink being larger than the depth of the etchings, a very imperfect impression is produced."[*]

159. But though these mechanical difficulties exist with respect to *printing* from an etched plate, yet the *etching* is perfect. The action of the liberated elements has produced, perhaps, the most delicate piece of workmanship ever seen; and though many practical difficulties will ever exist against successfully printing from such plates, yet the electrotypist possesses the means of multiplying the most faithfully and elaborately executed among them, with undeviating certainty; and of obtaining in metal as many perfect copies of the original as he may think fit to take. "To give an idea of the perfect accuracy of these, I may mention that in one I have taken," writes Mr. Grove, "on which is a sign-board, measuring, on the electrotype plate $\frac{1}{10}$th by $\frac{6}{100}$ths of an inch, *five* lines of inscription can, with a microscope, be distinctly read."

160. I can conceive, therefore, that among those into whose hands these pages may fall, are many who will value this discovery which furnishes a means of multiplying readily these treasures of ART, I was about to say; and possibly *art* is the fittest designation to give to this process which has arisen at the magic touch of *science*. It is true no living *artist* can produce pencillings so true and faithful, but science has called

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[*] Vide Proceed. Elect. Soc. p. 98.

into action the finger of nature, who is ever faithful and ever true; and has inscribed upon her productions, not the words "drawn by Landseer, and engraved by Cousins," but "drawn by Light, and engraved by Electricity."*

161. *M. Fizeau's Process.*—M. Fizeau has been most successful in engraving Daguerréotypes. He inserts the plate in a mixture of nitric, nitrous, and hydrochloric acids, by which means the black or silver parts of the picture are eroded: he then washes out the chloride of silver thus formed with ammonia, and again immerses the plate in the acids, repeating the process several times. A certain depth of etching is thus produced. He then rubs linseed oil on the plate, and washes it off so, that the parts in relief may be still exposed; he now gilds these parts by the electro process, and afterwards removes the oil by caustic potash; this being done, he bites in the hollow parts with nitric acid, and so augments the depth at pleasure. Now, as silver would soon wear out in the press, he coats the whole surface with copper by electric deposition, and thus prepares the plate for use; and when one surface of copper commences to wear, he removes it by chemical means, and supplies its place with a fresh deposite.

162. *New Mode of Etching.*—Dr. Pring has described † another mode of etching. A polished steel or other metal plate is connected with the positive end of a series of four or five, a good coil of coated copper wire being interposed between the plate and the battery. The other wire, guarded by glass or other insulator, is held in the hand and employed as an etching tool, when any device may be drawn. The magneto-electric machine will also furnish electricity for this mode. The plate may be reversed and connected with the

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* Vide Prof. Grove's paper.

† Vide Phil. Mag., Aug. 1843.

negative end to vary the experiment. Various wires may be used. No solution is employed.

IV. APPLICATIONS OF ELECTROTYPE, &c.

163. *Patents.*—In reviewing the patents taken out, (and there are not a few) I have felt some degree of difficulty in tracing the features by which the right of one is distinct from the right of another; and have almost doubted whether the patents are not based rather upon the nature of the *moulds*, than of the *power* employed. To one is allowed the peculiar privilege of making a wax model of a *stewpan*, and depositing copper upon this; to another the peculiar right of making the model of a *seal* by uniting some *printer's type*, and depositing copper upon this. I shall best succeed in conveying an idea of the extent to which this art has been patented, by extracting from the several specifications the general summaries on which the claims are based. And I doubt not that my readers will be somewhat surprised, when they find how the *principle* of electro-chemical decomposition,—for it is but a general *principle*,—has been seized upon and appropriated.

164. One has accomplished certain "improvements which have for their object the coating or covering manufactured articles composed of wrought or cast iron, lead and copper and its alloys, with copper or nickel; such coating being effected by means of galvanic electricity." Nor does he "confine himself to any particular arrangement of apparatus, but claims the mode of treating manufactured articles, of the *metal and* alloys above stated, so as to obtain a *permanent coating* or covering of copper or nickel."

165. With respect to plating, patentees claim "the

use of a solution* of silver, in prussiate of potash,† or other analogous salt, or in pure ammonia, in combination with a galvanic current;" and "the use of a solution of silver in acid, so as to constitute a neutral salt, in connection with a galvanic current; the articles in this (the latter) case having been previously coated with silver." Under the head of gilding, is claimed "the use of a solution, for the purpose of gilding, formed of oxide of gold, dissolved in prussiate of potash or soda, or any other analogous salt, and combining the action of a galvanic current with the use of a salt of gold as above, preferring the solution of gold formed by dissolving the oxide of gold in prussiate of potash; and, further, the patentees claim, with referrence to the two last heads of their invention, the application of a galvanic current, in combination with solutions of gold or silver for coating or plating with gold or silver, whether the articles to be so coated are formed entirely of metal or only partly so."

166. The same parties prepare surfaces of iron to receive a coating of copper or other metal, by connecting them with a piece of zinc and placing them in acid, so as to form a voltaic pair; "after a short time the scales and dirt will fall from the iron, leaving its surface perfectly clean and bright;" and fit to receive a coating of copper, and then one of silver or gold.

167. The right is claimed of etching on *iron or steel* by the electrolysis of a solution of common salt, and an iron or steel plate; on *silver*, by a solution of sulphate of soda or sulphate of silver, and a silver plate; on *gold*, with hydrochloric acid, and a gold plate; on *copper*, sulphate of copper and a copper plate; nor do the patentees limit their claim to the metals named, but "claim the use or application of voltaic electricity

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* It is stated "that it will be found necessary *to add from time to time a fresh supply of the oxide to the solution, in order that it may be kept saturated with that salt.*"

† Or rather cyanide of potassium. Vide § 95.

for engraving on metals generally;" and hence, I presume, within this COMPREHENSIVE clause is included the etching of Daguerréotype plates; although the latter process was not discovered until months *after* the patent was enrolled.

168. Another application of the art is to form rollers of copper for printing or embossing calicos, &c., by making a model of a roller, and, after rendering it a conductor by any of the ordinary means, depositing copper upon it;* also for thickening old cylinders, rollers, &c., for the same purpose; and for filling up portions of patterns that are to be obliterated.

169. Other applications of this process are described: "1st, in the production of a printing, embossing, or impressing metallic cylinder, plate, or block, having a device or pattern formed thereon, suitable for the above purposes; such device or pattern constituting *one perfect* or *connected* design, produced from an originally engraved or otherwise executed *portion* of the said design; 2nd, in a mode of *joining* together engraved or otherwise executed metallic plates, so as to form *one connected* surface; 3rd, in obtaining an *extended* plain surface to an engraved metallic plate, whereon a continuation of, or an addition to, the subject already formed may be engraved; 4th, in certain modes of producing *suitable* surfaces, as aforesaid, such modes not requiring the ordinary original process of engraving;† 5th, in a mode of producing surfaces, as aforesaid, such surfaces being suitable for printing,

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* This is merely a variation in the *form* of the mould.—(§ 163.)

† A flat metal surface is covered with varnish; the design is traced by removing the varnish; the whole is then covered with plumbago, (§ 39.) or rendered conductible by other means; and is placed as a mould in connection with the battery; or a lithographic stone is prepared and treated in a similar manner; or the *design is punched* in sheet-lead, and this is united to other metal, *and then deposited* upon.

›rinting or embossing in various colours;* 6th, in application and use of dies, formed by the agency oltaic electricity, for the purpose of embossing or ressing horn, hoof, or tortoise-shell, in the manu-ure of buttons; 7th, in the mode of mounting or ching seals, bookbinders' tools, or *other such* in-ments used for impressing, such instruments or s being produced by the agency aforesaid; and ly, in a mode of producing seals for impressing on or other such substances."

70. The object of another "*invention* is to produce ›s, boilers, stewpans, or other vessels of copper, ›ugh the agency of Voltaic Electricity;" by depo-›g copper on moulds of " clay, wax, plaster, or ›r like substances; or of lead or other metal, fusible lower temperature than copper." " Another part he invention relates to the joining together of several es, so as to form vessels; and by which means stop-ks, or other such parts, may be added to boilers, &c., ›ed by the above process."

71. The above is by no means a complete abstract ›atents, as our readers will have themselves dis-›red from many other processes that have been pre-ed to them in the course of this work. But we must ote the space that remains to a few subjects that have a place elsewhere.

72. In the preceding pages, I have dwelt on the ying of medals and plaster medallions alone. ugh, however, has been said to render the subject iliar, and to enable those who are successful in copy-the small objects here treated of, to carry their ex-ments to any extent. Busts, statues, vases, may, ›roper application of the principles laid down, be as lily coated with copper as the small wax moulds.

Two or more moulds, according to the number of colours, are ›ned from the *same* original; and from each are removed those ›ons *which are not to* be printed by the colour to which it will ›nfined.

(§ 32.) Yea—almost anything, to which a coating of plumbago can be given, may serve as a mould on which to deposit the metal. Gutta Percha, a new gum, which becomes plastic at less than 212° Fahrenheit, and hardens on cooling, will be often found a most convenient material for moulds. With no credit to my discernment, I might devise a thousand instances in which this art will be available in the common concerns of life; but rather leave the merit to him who shall actually introduce it into these several spheres. It may be found available in protecting from the effects of weather the busts and statues, which are introduced in ornamental gardening; and which are often, for the sake of economy, made of plaster of Paris. They may be saturated as described elsewhere (§ 40.); covered with plumbago (§ 32.), and placed within a large vessel whose sides are covered with copper, and then by means which must now be familiar to the reader, a deposition of copper may be formed on them: this can be bronzed by the simple application of the blacklead brush; and thus a sightly and permanent exterior will be produced. —By the same means small and valuable wax figures may be preserved; the surfaces of these are of themselves very liable to crack, and fall off in chips. A *thin* covering of copper, without in the least degree affecting the fineness of the workmanship, will preserve it. Busts and statues may be made in solid electrotype metal, by first coating a bust with thin copper, then embedding the whole in plaster or cement, afterwards breaking away the original bust, and finally making the mould that remains serve as a decomposition cell.

173. Electro-tint, or Galvanography.—Another form of deposite has been termed electro-tint. It consists in painting on white metal with etching ground or varnish:—the several shades are obtained by the *relative* thickness of the layers of varnish: the whole is then plumbagoed; and the deposite obtained on it is used as a plate to furnish prints. Prof. Von Kobell,

after obtaining a plate, examines a proof; and if too faint, he makes a mould of the plate; and having obtained a deposite, which will be similar to the original painted plate, he puts varnish on the parts which gave impressions too pale, and obtains a second deposite on this, which when removed will give prints of a better character.

174. Engraved copper plates may be readily multiplied by electrotype. The battery must be in proportion to the size of the plate, and the plate must be used in lieu of the moulds. Sometimes the copper deposite will adhere so strongly as to resist all attempts to remove it. This may be prevented by a very easy process. —Before the plate is used, heat it and rub bees' wax over the surface; continue the heat, and by the application of soft cotton, rub it perfectly clean from the wax; or the plate may be rubbed with blacklead in lieu of wax. In either case it may then be used without fear of adhesion. The deposite obtained on it is to be removed, and used as a mould, from which many copies may be taken equal, in all points, to the original. Sometimes moulds of medals and casts are made from originals in Electrotype copper.

175. *Glyphography* — is another application. A smooth copper plate is blackened by sulphuret of potassium, and is then coated with an etching ground, through which a design is traced. The high lights are now built up of non-conducting materials, so as to prevent their printing; the whole is coated with plumbago, and an electro-copper-plate is formed from it: the copper plate is afterwards soldered on a block of wood, and is used as a wood-cut; it is called an *electro-glyphographic cast.* Or this plate, after etching, has a plaster cast taken from it, and from this the high lights are cut out; it is then oiled, and a second cast is taken, from which a stereotype copy is to be made. This is called a *stereo-glyphographic cast.*

176. *Metallic cloth*—is prepared by Messrs. Elking-

tons, for various pnrposes. On a surface of copper is attached very evenly, stout linen, cotton, or woollen cloth: the copper is placed in a solution of copper, or other metal, and is connected with the negative pole of the battery: a sheet of copper, or other metal, as the case may be, is placed opposite, and in connection with the positive pole of a battery. Decomposition takes place, and the metal, in endeavouring to reach the metal plate, insinuates itself into the interstices of the cloth, and forms a perfect metallic sheet.

177. *Purity of sulphuric acid.*—As the great object of writing this treatise is to simplify the various stages of the process, I must not leave unnoticed a fact that has been pressed upon my attention, one which is of great practical importance,—the necessity of employing *pure* sulphuric acid; I mean, so far pure, as to be free from *nitric* acid. Very commonly a small portion of nitric acid is present, and this operates in a most destructive manner upon the zinc, defying all care and trouble in amalgamation: for it attacks some of the mercury, and leaves portions of the zinc exposed, giving rise to an amount of local action to no trifling extent; indeed it is the serious cause of objection to the use of the platinized battery: and has caused it to be rejected by many manipulators. This will explain the cause of amalgamation's failing far more effectually than the assumption of the impurity of the zinc. The latter is well concealed by the mercury; but the nitric acid undermines the other precautionary means, and militates most effectually against the permanent preservation of the zinc.

178. *Test for nitric in sulphuric acid.*—The presence of nitric acid may be determined by the following simple and effectual test.—Apply heat to a Florence flask, containing sulphuric acid, with which has been *mixed some* sulphate of indigo; should the blue colour *disappear,* nitric acid is present; should it remain, the *acid is good* and fit for use.—Besides exciting the bat

teries with the pure acid, it is also requisite to employ the same acid in the process of amalgamation. When these precautions are taken, the common rolled or cast zinc may be employed with impunity, and a *perfect* action will be obtained. Nitric acid may be driven off by boiling.

179. In reference to electrotype medals and other works of art produced in moulds taken from the originals, it may be as well to remark that there are two methods of giving them a silver or a gold surface by electric deposition; either by making the medal according to the instructions given in the First Part of this work, and then gilding or plating it; or by preparing a good and clean mould, (§ 28,) and depositing in it a certain quantity of silver or gold, and then backing it up by the deposition of copper. The best electrotype medals are produced in this way.

180. *Copying Busts, &c.*—It may not be out of place to add here the method pursued for copying busts or statues from *wax* originals. The original is covered in the usual way (§ 32.) with plumbago; it is then placed in the copper solution of a decomposition cell, (§ 56.) and is acted on until a moderate coat of copper is obtained: it is now removed and embedded in plaster of Paris; the wax is melted out, and the interior well cleaned with a hot ley of potash or soda. It is then inverted and filled with a solution of the metal which is to be deposited; and in the solution is placed a sheet of the same metal, as in the ordinary arrangements. The theory of this operation is self-evident; but in practice, especially on small articles, a difficulty presents itself, to guard against which requires no little care. The action occasionally ceases without any apparent cause; and for days, although all things seem in order, no appreciable deposite takes place. This can only be obviated by cleaning the positive *metal* and greatly reducing the action. The effect is

due to phenomena too complex to be detailed in the present treatise.

181. I have not space to make any lengthened comments upon the extensive applications of electrotype. I can fancy that scarcely one will read this treatise with attention, and reflect on the uses to which the art *has been* applied, without figuring to himself many others to which it *may be* applied. The science on which the whole of what we have treated is based, reminds one of that little cloud, dimly seen at first in the distance, no bigger than a man's hand, which gradually develops itself, until it enfolds within its spacious mantle the whole of the visible face of nature. Every day is bringing fresh evidence of the vast extent of the operations of electricity; although each fresh acquisition of knowledge only teaches us how *little* we really *know*. Scarcely do we elucidate one series of problems, than another, and another, and another, presents itself to our earnest gaze; and we are compelled, in summing up the results of even our most successful labours, to confess with the great philosopher, that we are like children on the sea-shore, who pick up occasionally one pebble of better value than the rest.

CHARLES V. WALKER.

Jan. 1, 1848.

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THE END.

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